LEEDS PHILOSOPHICAL
AND LITERARY SOCIETY

MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. LVI. JUNE 12, 1896. No. 9

A. A. COMMON, LL.D., F.R.S., President, in the Chair.

Rev. Frederick Lisle Bullen, the Rectory, Littleton-upon-Severn, Gloucestershire ; and
Ernest W. Ellerbeck, the Observatory, Scarborough,

were balloted for and duly elected Fellows of the Society.

The following Candidates were proposed for election as Fellows of the Society, the names of the proposers from personal knowledge being appended :—

George Alexander Sime Atkinson, 238 Newport Road, Cardiff, South Wales (proposed by H. W. Lloyd Tanner) ; and
John Burt Trivett, Computer, Trigonometrical Survey of New South Wales, Department of Lands, Sydney, Australia (proposed by Joseph Brooks).

Ninety presents were announced as having been received since the last meeting, including, amongst others :—

Chart of Southern Circumpolar Stars, presented by H. C. Russell ; Stellar Spectra, photographed at South Kensington with the 6-inch prismatic camera, presented by J. Norman Lockyer ; Enlargements from photographs of the region surrounding η *Argûs*, taken at the Royal Observatory, Cape of Good Hope, with exposures of 3^m, 1^h, $3^h\ 15^m$, 12^h, and 24^h, presented by David Gill.

An Answer to Certain Questions asked in the "Bulletin Astronomique," tome xiii, Mai 1896, *on Time Measurement.* By E. J. Stone, M.A., F.R.S., Radcliffe Observer.

In the *Bulletin Astronomique*, tome xiii, Mai 1896, there is a short review of my paper on the Corrections of the Epoch and Mean Motion required by Hansen's Lunar Tables.

The writer makes no remarks whatever on the accuracy with which the observations of the Moon 1750–1892 are represented by Hansen's Lunar Tables with the corrected epoch and mean motion; and I presume, therefore, that he is satisfied upon that point. See *Monthly Notices*, vol. lv. No. 2, p. 58.

But, with the exception of a slight ambiguity in the definition of the physical meaning of the linear quantity, a, which satisfies the identity

$$f = n^2 a^3,$$

a concise, clear, and accurate statement of the views upon which my work is based is given; and some questions are asked and some formulæ brought forward which deserve careful consideration.

The notation adopted is that, for a selected epoch, n represents the Earth's mean motion in heliocentric longitude in the adopted unit of time measured from the mean equinox at epoch; ω, the constant angular velocity of the Earth about its axis in the unit of time; f, the accelerating effects of the Sun's mass taken as the unit of mass in the unit of time at the unit of length; a, a linear constant which satisfies the condition

$$\left(\frac{f}{n^2}\right)^{\frac{1}{3}};$$

p and q, the mean regressions in longitude and right ascension respectively of the true equinox from the mean equinox at epoch:

$$\mathrm{N} = n + p : \Omega = \omega + q.$$

In order that these quantities may be combined in our mathematical investigations, it is, of course, absolutely necessary that n, ω, p, q, and f should be referred to the same unit of time, and f and a expressed in terms of the same unit of length, and that the same units should be employed for the expression of all the time quantities and linear quantities which appear in our formulæ.

The *exact* numerical values of the physical quantities represented by n, ω, p, q, f, and a will vary, according to well-known laws, with any changes which we may introduce into the units; and in tracing the effects of errors made we must proceed from exact equations to their approximate forms.

But if the units are not changed by us they cannot change. The writer asks—

"Qu'est-on en droit de conclure lorsqu'on arrive, par une nouvelle discussion des observations, à une nouvelle valeur de $\frac{\omega}{n}$, l'invariabilité de la rotation de la Terre et de la constante de l'attraction étant admises? Indépendamment de tout choix d'unités, on a

$$\frac{\omega}{n} = K, \quad f = n^2 a^3, \quad \text{puis } \frac{\omega}{n'} = K', \quad f = n'^2 a'^3,$$

d'où

$$\left(\frac{a'}{a}\right)^3 = \left(\frac{n}{n'}\right)^2 = \left(\frac{K'}{K}\right)^2;$$

on ne peut conserver la même unité de longueur si le demi-grand axe calculé est toujours pris comme unité; il y a contradiction et discontinuité. Il est clair qu'on ne peut espérer assurer la continuité absolue des unités de temps et de longueur alors qu'elles sont empruntées, pour une certaine part, au mouvement de la Terre autour du Soleil.

"Pour suivre M. Stone dans son raisonnement, nous voyons bien que dans une première discussion $\frac{\omega}{n}$ doit être, pour une valeur adoptée de l'unité de longueur, indépendant de l'unité de temps; la même chose aura lieu pour les nombres provenant d'une seconde discussion; mais quel droit a-t-on de conclure *a priori* à l'identité des deux valeurs de $\frac{\omega}{n}$ quelle que soit l'unité de longueur?

"La substitution, en 1864, des Tables de Le Verrier à celles de Carlini a introduit une discontinuité dans l'unité de temps. Quelle a été, pour M. Stone, la modification de l'unité de longueur, et de quelle manière assure-t-il la continuité des mesures de longueur?"

The differences between the angles n', or mean motion in geocentric longitude of the Sun from true equinox minus mean precessional motion, thus found from a discussion of solar observations, and the angle n adopted to fix the scale on which the accelerating effects of the different masses are measured, will be due to one of the following causes or their combination :—

Firstly. The difference may be due to errors in the adopted value of the precession constant, p, employed to pass from the mean motion in longitude measured from the true equinox to that from the mean equinox. The adopted value of the precessional constant should in this case be altered; and it is clear that we should not change the angle n adopted for the Earth's mean motion in heliocentric longitude, measured from the equinox at epoch in the unit of time, from n to n', and the accelerating

effects of the Sun's mass in the unit of time from n^2 or n^2a^3 to n'^2 or n'^2a^3, because n' thus found differs from n.

Secondly. The difference may be due to errors in the observations. In such a case it is also clear that we should not change the angle adopted for the Earth's mean motion in heliocentric longitude in the unit of time from n to n', and the accelerating effects of the Sun's mass in the unit of time from n^2 or n^2a^3 to n'^2 or n'^2a^3, but should wait for a longer series of solar observations.

Thirdly. The difference may be due to the neglect in our theoretical expression of the Earth's longitude of long inequalities of the form

$$\mathrm{P}\sin(ct+d),$$

where P, c, and d are constants.

In this case, also, we ought not to change the angle adopted for the Earth's mean motion in heliocentric longitude from n to n', and the accelerating effects of the Sun's mass from n^2 or n^2a^3 to n'^2 or n'^2a^3 ; but the theory should be revised and the long inequalities computed on the scale fixed by the adopted angle n ; and the effects should be duly allowed for in the discussion of the solar observations.

Fourthly. The difference between n and n' may be due to errors in our methods of finding the variable t from observation, or in referring the tabular positions of the centre of gravity of the Sun to the meridians of the observers. In this case, if t' is the value thus found, instead of t we should have, if the effects of the other sources of error were practically insensible,

$$(n'+p)t' = (n+p)t.$$

In such a case, as the variable t' is not the required variable t, we should, instead of altering n to n', correct the variable t'. It would not be of much practical importance whether we considered $n'-n$ as a correction on n, or $t-t'$ as a correction on t', if the disturbing effects of the planets were insensible ; but as such is not the case, and these effects have to be estimated on the scale adopted in fixing the value of f, the use of t' for t will injuriously affect all our results proportionately to the magnitude of the factors of t, and corrections for the differences between t and t' must be applied in order to secure accuracy in the results. But perhaps it may be considered that no such error as the use of t' for t has been proved to have been made by astronomers. There is, however, no difficulty in proving that such errors are made in practice. But these proofs all turn upon the fundamental assumptions that *n represents the Earth's mean motion in longitude in the unit of time, and that we replace f by n^2a^3 in our mathematical work.*

In this case, if the physical quantities are denoted by n, ω, p, q, and f when referred to the unit of time fixed by the condition

$$f = n^2a^3,$$

and by $n_\circ$, $\omega_\circ$, $p_\circ$, $q_\circ$, and $f_\circ$ when referred to a "unit of time" fixed by the condition that $f_\circ = n_\circ^2\, a^3$, where $n_\circ$ is such that

$$\omega_\circ + q_\circ = 365{\cdot}25 \times 2\pi + n_\circ + p_\circ,$$

or

$$\Omega_\circ = 365{\cdot}25 \times 2\pi + \mathrm{N}_\circ,$$

we shall have, with *exact* quantities,

$$\frac{\omega_\circ}{\omega} = \frac{n_\circ}{n} = \frac{q_\circ}{q} = \frac{p_\circ}{p},$$

$$\therefore\ \omega + q = 365{\cdot}25 \times 2\pi \times \frac{n}{n_\circ} + n + p,$$

$$\text{or } \Omega = 365{\cdot}25 \times 2\pi \times \frac{n}{n_\circ} + \mathrm{N},$$

$$\text{or } \Omega = 365{\cdot}25 \times 2\pi + \mathrm{N} + 365{\cdot}25 \times 2\pi \,.\, \frac{n - n_\circ}{n_\circ}.$$

These formulæ also follow directly from the difference between the exact ratio of the mean sidereal day to the mean tropical year at epoch and that assumed by astronomers in practical work.

But astronomers in practical astronomical work erroneously replace

$$\Omega = 365{\cdot}25 \times 2\pi \times \frac{n}{n_\circ} + \mathrm{N},$$

$$\text{by } 365{\cdot}25 \times 2\pi + \mathrm{N},$$

although different values of n are adopted for the same epoch. And, as a consequence of the error thus made, when referring the positions of the centres of gravity of the Sun, Moon, and planets to the meridians of the observers, and in finding the time, t, from observation, they have taken out the *tabular* R.A. of the meridian, expressed in circular measure, for the time, t, in error by

$$-2\pi \,.\, 365{\cdot}25 \,.\, \frac{n_\circ - n}{n_\circ} \,.\, t;$$

and all the terms in our theoretical expressions which contain t as a factor are thus proportionately affected with errors due to the neglected term.

It is true that the exact value of $n_\circ$, and therefore of

$$\frac{n_\circ - n}{n_\circ},$$

for an assigned value of n, and a definite epoch, is at present unknown; but if we include in the expressions for t, as directly found from observation, the effects of the neglected terms, we have the means of finding $n_\circ$ by continuous approximation from

the observations. And, although $n_o - n$ is at present unknown, we know the difference in the errors made with two different adopted values n and n', viz. $n' - n$; and I have shown that the effects of the neglected terms due to the difference $n' - n$ for the values adopted for the Sun's mean motion in longitude in the unit of time in the solar tables which were employed, before and after 1864, to bring up the stellar places from one epoch to another, to reduce the geocentric places to heliocentric places, to refer the positions of the centres of gravity to the meridians of the observers, and to find the time, t, are sufficient to perfectly account for the increase in the errors of Hansen's Lunar Tables in longitude, which, as a matter of fact, set in *per saltum* about 1864, and has continued since, until it now amounts to about 22″.

I hope that I have here given a clear and distinct answer to the question, "What conclusion ought to be drawn when a new value n' of n results from a new discussion of solar observations?"

The difference between n and n' will be due to the causes which I have indicated, and in none of these cases is there any necessity for changing the numerical value of the accelerating effects of the Sun's mass at the unit of length in the unit of time ; nor is there any means of evading the consequences if we make the change.

I now proceed to show why the writer of the review is led to physical inconsistencies by changing n into n'.

If the conditional equation

$$f = n^2 a^3$$

is true when any unit of time is adopted to measure the Sun's mean motion in longitude, which is here denoted by n, and any unit of length to measure the linear quantity, denoted by a, it is certainly true for any units of length and of time which we can adopt.

For f, the measure of the accelerating effect of the Sun's mass—

$$\propto \text{ as } \frac{(\text{the unit of time})^2}{(\text{the unit of length})^3},$$

and

$$n^2 \propto (\text{the unit of time})^2,$$

and

$$a^3 \propto \frac{1}{(\text{the unit of length})^3}.$$

The unit of time in terms of which f, n, ω are expressed is a matter of choice on the part of the mathematician, but *if n does express the Sun's mean motion in geocentric longitude in the unit of time* we certainly fix the unit of time when we assign a definite value to n, and the same unit of time must be adopted for the expression of f and ω. And, with regard to the unit of

length, we can, if we please, adopt the linear quantity, which satisfies the condition of being equal to

$$\left(\frac{f}{n^2}\right)^{\frac{1}{3}}$$

as the unit of length ; and, with this unit, we have the accelerating effects of the Sun's mass accurately measured by n^2. *If we adopt these units in our mathematical work we clear f from fallible errors of determination, and it is a constant throughout our work* ; but we have to express all the time quantities and the linear quantities in terms of the units of length and of time thus deliberately selected, and we must accept any practical inconveniences which may result from the choice of units thus made.

But we need not select this particular unit of length. We can select a, the linear constant introduced into the primary differential equations of the Sun's geocentric motion, or the semi-axis major of the undisturbed orbit as our unit of length. In this case we shall have, if ν_3 denotes the ratio of the mass of the Earth to that of the Sun,

$$f = n^2a^3 = \frac{n^2a^3}{1+\nu_3}\left(1+\frac{\delta a}{a}\right)^3 = \frac{n^2}{1+\nu_3}(1+\delta a)^3$$

when a is taken as the unit of length.

The correction δa will be a function of the disturbing masses, and must be found in terms of the adopted unit of length from the mathematical investigations. This is the method which Le Verrier followed, and it is clear that any change which we may make in n will change the unit of time in terms of which

$$\frac{n^2}{1+\nu_3}\cdot(1+\delta a)^3$$

will measure the accelerating effect of the Sun's mass, but not the unit of length ; and that the unit of length is different when we adopt

$$n^2a^3, \quad n^2, \quad \frac{n^2}{1+\nu_3}(1+\delta a)^3$$

for the accelerating effects of the Sun's mass at the unit of length in the unit of time ; and *neither the unit of length nor the unit of time can change unless we change them.*

Now the writer is directly led to physical inconsistencies and discontinuities, because, after adopting values of n, ω, and f, referred to a definite unit of time fixed by the condition that the assigned angle n shall be the Sun's mean motion in geocentric longitude in the unit of time, he assumes that he can adopt for the mean motion of the Sun in geocentric longitude in the unit of time an angle n' instead of n, and can yet assume that the values of ω and f are not proportionately changed. The conditions thus introduced are physically impossible relations between ω, f, and n'.

The results thus arrived at agree identically with those which I have obtained. I have shown that, unless we admit the possibility of discontinuities in our unit of time, we must, when we change n to n', change ω to ω', and f to f', such that

$$\frac{n}{n'} = \frac{\omega}{\omega'} = \frac{\sqrt{f}}{\sqrt{f'}}.$$

Similar remarks refer to the unit of length.

The linear quantity a cannot be changed without changing the unit of length, and thus changing the *numerical measure* of the accelerating effects of the unit of mass at the *unit of length* in the unit of time.

If the mean sidereal day were taken as the unit of time, the angle n in terms of this unit would become an angle determinate only as a fallible quantity from observation. It would be liable to not only mere chance errors of observation, but to the effects of any neglected long inequalities in the expression of the Sun's longitude : and the use of n^2a^3 for f under such circumstances in our mathematical work would render f a variable quantity instead of a constant. And the errors thus introduced in our mathematical work would be of the same class, but of a more involved character, as those which led to the prolonged discussion on the value of the secular acceleration of the Moon's mean motion.

My contention here is that neither the mean sidereal day nor any assigned definite multiple of that interval of time is adopted as the unit of time in the formation of the differential equations of motion of gravitational astronomy, or that the integrations are erroneously carried out in terms of the variable. Similar remarks apply to the adoption of the physical "mean solar day." The angle n_0 required to fix such a unit of time is at present unknown.

The mathematical results obtained by the writer of this review agree with those which I have obtained ; and it would appear that the choice lies between astronomers accepting the fact that they have overlooked and neglected the effects of the small terms

$$\frac{n_0 - n}{n_0}$$

in finding their time from observation, or assuming the possibility of the investigations of mathematical astronomy being carried on with units of length and of time, which are discontinuous, and of which the laws of discontinuity are unknown.

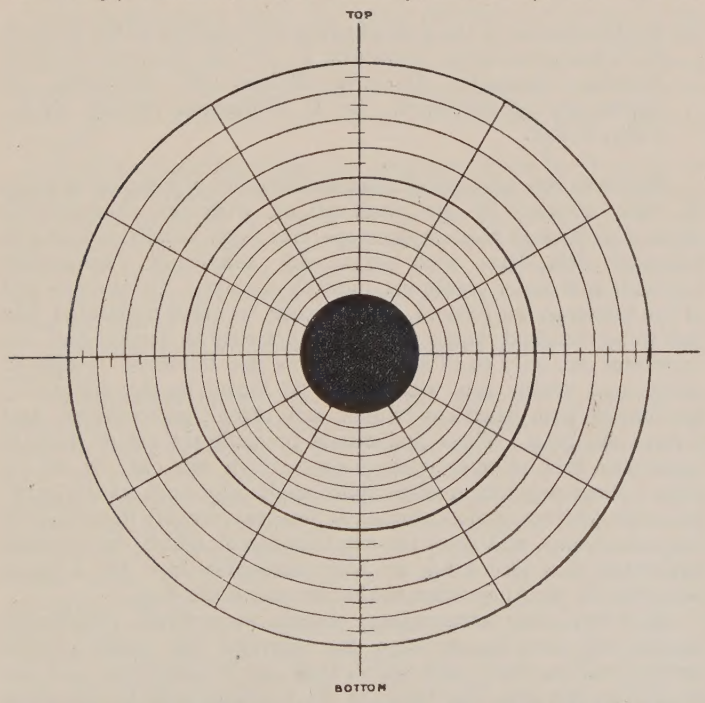
The effects of the errors indicated in finding the variable, t, from observation, when $n_0 - n$ is not zero, must be duly allowed for in our work before any inferences respecting the inaccuracy of the law of gravitation or sensible instability in the rotation of the Earth about its axis can be discussed with advantage.

Solar Eclipse without Instrumental Means. By E. J. Stone, M.A., F.R.S., Radcliffe Observer.

A considerable number of persons keenly interested in astronomy, but unprovided with instrumental means, will, if the weather prove favourable, see the eclipse of 1896 August 9 in Norway.

It has occurred to me that such observers might render a service to astronomy if they were to follow out the plan I recommended, and which was carried out under somewhat similar circumstances for the observations of the eclipse of 1874 in South Africa.

The corona consists of a comparatively bright inner part lying close to the Sun, surrounded by a much fainter mass of luminous matter of vast extent, and generally of most irregular form, which does not yet appear to have been successfully photographed to its full extent. Accurate drawings of the outline will be exceedingly valuable, and, fortunately, inaccuracy, such as affects



the scientific value of the drawings, can be avoided if the following precautions are taken : Those persons who intend to make sketches should provide themselves with a sheet of paper about 9 inches wide by 12 inches long, having upon it a black disc

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$1\frac{1}{4}$ inch in diameter to represent the Moon, from the centre of which concentric circles and straight lines at angles of 30 degrees are drawn, as in the accompanying diagram, to place correctly the outlying portions of the corona in position and to scale. A weight must be suspended by a string in such a position that the observer can see it hanging over the Sun's centre, and the diagram upon which the drawing is to be made so placed upon a convenient stand that the line marked "top," "bottom" shall be in the plane passing through the observer's eye, the string, and the Sun's centre; the end marked "top" of the diagram must correspond to the top of the string.

It may be desirable that two or three minutes before totality the observer should cover his eyes, to render them sensible to feeble light, leaving it to a friend to warn him when totality begins; but this should not be carried far enough to strain the eyes.

On the Equipment of the Astrophysical Observatory of the Future. With two Appendices: Appendix I.—On the Support of Large Specula; Appendix II.—On Making the Siderostat an Instrument of Precision. By G. Johnstone Stoney, M.A., D.Sc., F.R.S.

Hitherto the scrutiny of separate celestial objects, or of fields of view, whether by eye observations, with the photographic camera or through the spectroscope, has been carried on amidst practical difficulties with equatorial telescopes expensively mounted and under cumbrous movable domes. To the eye end of the telescope the camera, spectroscope, or other apparatus has had to be attached under conditions not easy to secure, and the apparatus can only be of such a kind as the telescope is able to carry, and which may with safety be borne by the equatorial movement into positions which are often inconvenient and always changing. These limitations preclude the use of delicate apparatus, such as micro-radiometers, which can only be set up upon a fixed support, or of complex appliances, such as the apparatus for producing monochromatic images, recently described by Captain Abney, and from the employment of which, or of other apparatus of a like kind, we may reasonably look for a great accession to our knowledge of the physics of the Sun.

However, the extraordinary success with which instrument makers can now figure large flat mirrors, the much greater facility and certainty with which they can be resilvered, and the possibility of supporting them in all positions with the requisite delicacy and without risk of shifting their line of collimation, by the arrangement described below in Appendix I., give an opportunity of remedying all this. We have it thus within our power

to equip an equally efficient and much more convenient astrophysical observatory at a less cost than hitherto, or by an equal expenditure to furnish one which can accomplish much more.

There are four ways in which the flat speculum may be employed : in the ordinary siderostat, described early in the eighteenth century by s'Gravesande ; in the polar siderostat ; in the modification of the polar siderostat, suggested some years ago by Sir Howard Grubb, in which the objective is outside the flat mirror, and is, along with it, carried round by the polar axis ; or, finally, in that very meritorious instrument the cœlostat, an instrument of which the polar axis is driven round once in forty-eight hours. An instrument driven in this way was constructed and described by Mr. Conrad Cooke many years ago, but its real value was not known till it was pointed out by M. Lippmann last year, that the image furnished by it does not rotate in the field of view if the mirror be placed strictly parallel to the polar axis. All of these have their special advantages and disadvantages, and it is probable that a fully-equipped astrophysical observatory should possess more than one of them.

For photographic work the polar siderostat, whether in the usual or in Sir Howard Grubb's form, and the cœlostat, offer the greatest advantages in dealing with all parts of the sky, except a small region in the immediate neighbourhood of the pole, for which special provision, not difficult to contrive, would have to be made.

With the polar siderostat the telescope must be placed in or parallel to the polar axis. The telescope may be either stationary in the axial position or carried round by the axis, but, in any case, the camera must be attached to the moving axis and rotate with it, in order that the image may remain in one fixed position upon the photographic plates. A spectroscope when used with a polar siderostat may be set up in one fixed position whenever, as is usual, the rotation of the image in the field of view is immaterial.

Astronomers have a well-founded distrust of convertible instruments ; but the structural provision which would have to be made in order to convert a polar siderostat into a cœlostat is of such an extremely simple and unobjectionable kind that it is probable that the same instrument could safely be made to serve in both capacities. When used as a cœlostat, the telescope with its camera, or other apparatus, is to be mounted on a nearly horizontal table, which can traverse round in azimuth, and slope upwards and downwards through a few degrees. There are many kinds of bulky or delicate apparatus which would admit of these motions, although they could not be carried into the positions into which an equatorial would sweep them ; so that the range of work which can be done in the observatory will be increased.

When, however, we want to use the most powerful spectroscopes, such as Rowland's largest concave gratings, or very deli-

cate instruments, such as Professor Boys's radio-micrometer, the ordinary siderostat, s'Gravesande's siderostat, if it can be perfected, offers immense advantages, since the telescope and associated apparatus can remain immovable in a horizontal position, while all requisite adjustments are made upon the siderostat. These are matters of great practical convenience. It is to be remembered that the only defect which the siderostat has, namely, that the image furnished by it slowly rotates in the field of view, is of no detriment for stellar spectroscopy. By employing a s'Gravesande's siderostat, therefore, we may bring much more powerful appliances than heretofore to bear on the spectroscopic examination of stars, and we shall use them under the most convenient conditions.

The only inferiority of this instrument to the polar siderostat as an instrument of precision lies in the sliding motion which has always hitherto been made use of in it. But a model which was exhibited at the meeting, and which is described in Appendix II., shows that this sliding motion may be got rid of, and a continuous motion substituted, with details that possess every quality which is essential for extreme astronomical precision. With this improvement the s'Gravesande siderostat becomes an instrument that can be relied on in the astronomical observatory, and will be found probably much the most useful form of siderostat for all work which is compatible with the image rotating in the field of view.

What I suggest accordingly is, that the astrophysical observatory of the future be furnished with a polar siderostat convertible into a cœlostat, and where practicable with an ordinary siderostat also, instead of with an equatorial ; and that whatever is saved by the less expensive mountings and roofs, be employed in increasing the size and excellence of the mirrors and objectives. It is anticipated that in this way an astrophysical observatory may be constructed for carrying on the whole of the existing work with increased facility, and that it will besides bring within our reach important new branches of work, and extensions of the older work, which have hitherto been impracticable.

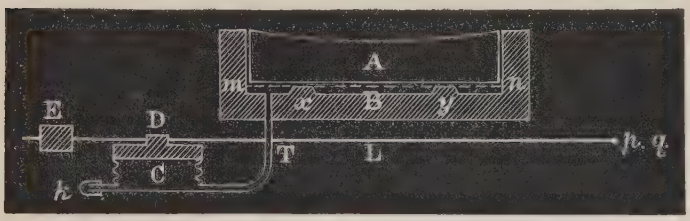
Appendix I.

On the Support of Large Specula.

The chief obstacle to the use of large specula in the astrophysical observatory, and especially for photographing the heavens, is that shifting of the line of collimation to which they are liable when the mirror is made to follow the motion of the celestial object.

The difficulty in preventing this shifting of the line of collimation arises out of the necessity for applying an extremely equable pressure over the back of the mirror which shall vary in amount according as changes in the altitude bring more or less

of the weight of the speculum to act upon its back support; and the necessity for avoiding the pinch to which changes of position or unequal expansion are apt to give rise. In the case of large specula the support is usually "a bed of levers," which, to act with the requisite delicacy, must somewhat yield; and when it yields, it is difficult—and with the largest mirrors practically impossible—to prevent some slight shifting of the plane of the mirror, which, of course, alters the line of collimation, and, for example, makes it impossible to take the best photographs with these great instruments, which otherwise would be the best for the purpose.



In the proposed arrangement the bed of levers is got rid of, and a pneumatic support takes its place. The mirror is mounted in a cell which takes the edgewise pressure, and in which it may be held without pinch and as nearly rigidly as an object-lens, if at the same time the back of the mirror receives such an equable pressure over its whole surface as shall exactly balance the normal component of its weight.

This is accomplished as follows. The cell is divided into two chambers, A and B, in the upper and larger of which the mirror is situated, resting on three props, *x y z*, of which two are shown in the figure, and which come into action only when there is insufficient air in the lower chamber.* An air-tight partition of thin flexible sheet-metal, represented in the figure by the dotted line *m n*, is to separate the lower from the upper chamber. This partition should be corrugated somewhat like the top of the vacuum chamber of an aneroid barometer, to provide for the difference in expansion between metal and glass. The lower chamber B may be very shallow—in fact, a mere chink. It communicates through the tube T with the regulator C, which is another air-chamber. In many cases this regulator may simply be a common air-cushion of appropriate size, in which the air is compressed by the disc D, which is forced against it by the lever

* Or, if it be found that there is risk of strain beyond the limit of elasticity when there is insufficient air, a bed of levers within the chamber B may take the place of the three props. When the proper amount of air is introduced it just relieves the pressure from the props or bed of levers, so that the latter only act while there is insufficient air.

L, at one end of which is the counterpoise E, and at the other end of which are the pivots p and q, one of which is above and the other under the plane of the section represented in the diagram. The whole of this apparatus is to be attached to the cell carrying the speculum, so as to accompany it in its motions. By this arrangement only one component of the weight of the counterpoise and lever acts on the regulator, the components which are parallel to the plane of the speculum being supported by the pivots p and q. In this way the air in the regulator, and consequently the air in the chamber under the mirror, is in all positions compressed in exactly the proper degree to support the normal component of the weight of the mirror. K is a nozzle through which air may be pumped in, if in the course of time there should be some leakage. The amount of the compression and the variations of pressure, even for so great and so heavy a mirror as either of Lord Rosse's two great six-foot mirrors, one of which weighs four tons and the other three tons and a half, are so slight that they would in no sensible degree interfere with the accuracy of the working of the arrangement; and with it the line of collimation can be kept as rigidly fixed in relation to the cell as any astronomical work requires. The mirror, of course, will need to have been ground and polished upon a similar support, as large mirrors do not admit of any alteration being made in their support without deformation.

In a small working model which was shown at the meeting of the Society, a large ordinary air-cushion took the place of the chamber B and the regulator C. It was in a chink between two boards, in the upper of which boards were two circular holes; the larger one to allow a twelve-inch speculum to rest upon the air-cushion, and the smaller one for a wooden disc pressed against the air-cushion by the counterpoise and lever. The boards prevented any expansion of the air-cushion, except where the mirror and counterpoise reached it.

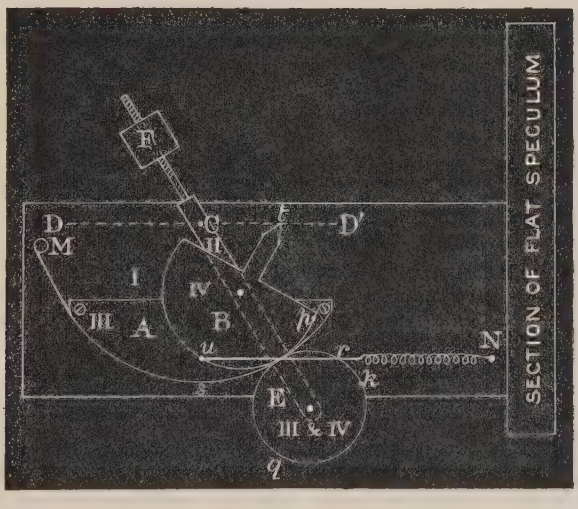
Appendix II.

On making the Siderostat an Instrument of Precision.

When the difficulties in the support of the flat mirror are fully got over (see Appendix I.), the chief obstacle to making the siderostat an instrument of astronomical precision lies in the necessity of providing a rectilinear motion between the mirror and that arm which the clockwork acting on a polar axis keeps pointed either directly towards or directly away from the celestial object, while the latter travels across the sky in its diurnal course. Hitherto this rectilinear motion has always been effected by a tube fitted upon the end of the arm sliding along a straight bar attached to the mirror, an arrangement which cannot always be relied on for extreme astronomical accuracy. Attempts have been made to substitute a continuous motion for this sliding

motion, but hitherto without getting over the practical difficulties. But the following arrangement appears to meet these difficulties so satisfactorily, that with it s'Gravesande's original pattern of siderostat, now commonly known as Foucault's, or that other type which the present writer adopted in the small "local heliostats" intended for use in physical laboratories, can either of them be made instruments of as great precision as the equatorial telescope.

In order to provide the rectilinear motion, use is made of the well-known kinematical principle, that if a circle roll on the inside of another circle of double its diameter, each point on the circumference of the smaller circle will traverse a diameter of the larger circle backwards and forwards. A working model was exhibited to show how this principle is to be applied, the essential



parts of which are represented in the accompanying diagram. M N is a sole-plate to which the apparatus is attached, and it lies at the lowest level in the diagram, which is indicated by the number I upon it. Next above it, indicated by the number II, is the lever E F, which turns on the pivot C standing up from the sole-plate. In the next tier, indicated by the number III, stands A, an arc of the larger circle, which is attached to the sole-plate, but propped up from it by two blocks at its ends, so as to leave space enough between for the lever E F to play. The pivot C is at the centre of this larger circle, and D D′ is one of its diameters. In the next tier, indicated by IV, is the small circle B of half the diameter of the larger. It turns on a pivot which stands up from the lever E F. Another pivot, standing up from

this lever, carries the idle drum E, which is rather more than twice as thick as A or B, so that the lower part of it is at the level of tier III and the upper part at the level of tier IV. Round the upper part passes a flexible steel band which is fastened at k, and from that goes in the direction $k\,q$ to p, where its other end is fastened to the wheel B. At the lower level another steel band is fastened at k, which passes in the direction $k\,r\,s$, round the larger wheel on to M, where it is fastened to the sole-plate by some contrivance which allows it to be a little lengthened or shortened at will. By this arrangement, if both bands are kept taut, the wheel B is made *to roll on the inside* of the wheel A. The steel bands are kept taut by the spring $N\,u$, which is attached to the sole-plate at N, and to the wheel B at that point on its circumference which is opposite to the pointer t. This point u, like every other point on the circumference of the wheel B, traverses a portion of a diameter of the larger circle A, which in this case is a short part of the vertical diameter in the figure ; and if N is placed sideways at the height of the middle of this short part, the spring will scarcely lengthen or shorten during the motion, so that even if strong, it neither throws a sensible amount of energy into the moving system nor withdraws sensible energy from it during the motion : in other words, the spring may be strong enough to effectually prevent all back-lash, and will notwithstanding allow the movement of the apparatus to be sensibly smooth and unimpeded throughout its whole range, a matter of importance in an instrument to be driven by clockwork.

During the motion, t, which is also a point on the circumference of B, traverses one of the diameters of the larger circle A, and this can be made any desired diameter, D D′, by adjusting the length of the second steel band at M, where provision for making this adjustment can conveniently be made. In the Foucault type of siderostat it is, of course, to be adjusted so as to be perpendicular to the reflecting surface of the flat mirror.

The whole arrangement has, therefore, to be attached to the back of the cell carrying the flat mirror. If rigidly attached, a universal joint of some kind must be provided where the end of the arm carried by the polar axis is connected with the end of the pointer t, which is the point that is constrained to move in a straight line perpendicular to the mirror. If attached in this way, the planes of the wheels A and B continue vertical throughout the motion. Another mode of attachment is to mount the whole so as to swing on a straight bar attached perpendicularly to the back of the mirror, so that the axis of the bar shall occupy the position marked in the figure by D D′. In this case a ring, which shall pass round this bar without touching it, must take the place of the pointer t, and with this the arm of the polar axis may be more simply connected. If mounted in this way the new apparatus will shift part of the way round the bar during the motion. But whichever arrangement is adopted, one counterpoise F will balance the moving parts in all positions. It will probably be

found convenient to duplicate the lever E F, and place half or a certain portion of the counterpoise at the end of each duplication, so as to keep the counterpoise clear of the polar axis and its arm in every position.

On the Importance of Accurately Observing the Leonids this Year.
By G. Johnstone Stoney, M.A., D.Sc., F.R.S.

The *Leonids*, the great November swarm of meteors, is the meteoric stream about which astronomers know most.

This great body of meteors traverses an immense oval orbit which, near its farther apse, crosses the path of the planet *Uranus*, and near its perihelion crosses the earth's path. The meteoric orbit does not intersect the orbits of the intermediate planets, *Saturn*, *Jupiter*, and *Mars*, owing to the considerable inclination of its plane. Round this great inclined orbit the meteors glide in a stream which lengthens as it moves inwards towards the Sun, and becomes shorter during each outward journey. Where the swarm passes the Earth it is about 100,000 miles thick, and of such a length that, though it travels at the rate of 27 miles a second, the great procession takes two years to pass us, and when its hinder part is still with us, its front will have reached to between the orbits of *Jupiter* and *Saturn*. Nevertheless, although so immensely long, it extends over only a portion of the circumference of its own great orbit, which it takes about a third of a century to traverse.

The front of this great swarm will next reach the Earth's orbit late in the spring of 1899. The Earth will then be in a distant part of its orbit, but in the middle of the following November and in November 1900 it will pass obliquely through the mighty stream, and on each of these occasions there will be an astounding rain of meteors, probably for about five hours, on the whole of the advancing side of the Earth.

Now, when we have regard to the fact that these meteors are not visible in outer space, and that we can only, and only for a second or two, observe that small proportion of them which happen to flash into some part of our small atmosphere, it is truly astonishing that it has been possible to gain so much knowledge of their movements and history.

Astronomers may be divided into two classes—chamber astronomers and observers. Sir Isaac Newton was the greatest of the former class, and the late Professor Couch Adams was one of the greatest of modern times. To him and to Professor H. A. Newton, of New Haven, we chiefly owe the great discovery. Before the visit of the meteors to the Earth in 1866 and 1867, Professor Newton pointed out how to deal with the problem, but it was by a process so difficult that it remained doubtful whether

any mathematician could successfully grapple with it. He also called the attention of practical astronomers to a datum which was wanted and which could be supplied by observation. Owing to his forethought, the requisite observations were made on the morning of 1866 November 14 (civil time), and immediately afterwards Professor Adams set to work to employ the material so furnished in the way that Professor Newton had indicated. In the following May, after five months of arduous labour, he was able to announce what the real orbit of the meteors is.

The *Leonids* are at present advancing inwards towards the Earth. They cannot be seen, but their position can be calculated, and it would be possible to determine to what part of the Earth's orbit they present themselves most endlong. Though not visible to the eye, it is quite possible that they may be photographed, and we have among us astronomers especially competent to make the attempt.

There is a comet in the track of these meteors. It will reach its perihelion before them. All the information about this comet which industry can glean from former observations should be thoroughly elaborated and put together in time to make full use of it when the comet reappears ; and when that occurs all the elements of the comet's orbit, and, if possible, its apsidal motion, should be determined with the utmost precision, to aid in tracing whether the comet was once perturbed by the Earth, like the stray *Leonids* seen annually. Whatever knowledge, too, spectroscopic scrutiny would furnish may prove of use.

A desideratum of special theoretical importance, and one which requires that observers should at once be on the alert, is as exact a determination as possible of the day and hour of apparition, and of the path in our atmosphere, of such outlying portion of the swarm as may precede the principal stream or follow it by one or more years. On the last occasion observations of this kind were made chiefly after the great visitation had taken place. It is of importance that on this occasion equally full observations shall be made in the years preceding it, *i.e.* in the present year and in 1897 and 1898. It is desirable that, wherever possible, concerted observations shall be made from different stations ; that they be much more exact than heretofore, and therefore made photographically when possible ; also, that they shall extend to a few days before and a few days after the 14th and 15th of November, inasmuch as we do not yet know on what dates to expect the advent of the avant-couriers of the principal swarm.

It is necessary here to keep in view the distinction between real advanced members of the great swarm, and mere scattered *Leonids*, a few of which are seen every year. The true forerunners of the swarm will, presumably, present themselves only within a brief definite period of time, extending to something like five hours, whereas a sprinkling of sporadic meteors may be met with for several days. These stray meteors seem to be meteors near to which the Earth chanced to pass in one or other

of its transits through the swarm, and which were by the Earth deflected a little from the true meteoric orbit. It does not appear that any special use can be made of observations upon these scattered *Leonids*.* But accurate observations of the true avant-couriers are specially wanted, and the importance of these observations will appear from what follows.

We come now to the chief matter which should be kept in view. The meteors are not a compact cluster, but drawn out along a considerable portion of their orbit. This, as Schiaparelli pointed out, is consequent upon there being differences between the periodic times of the individual meteors. Those that come round fastest get ahead, those that have the longest periodic time lag behind. Thus the stream is one that is lengthening century after century, and we can look back to a time when the whole must have been a compact cluster.

Now there is reason to conjecture that it was in the early spring of the year A.D. 126 that this lengthening out of the group commenced; for Le Verrier discovered that in the end of February or beginning of March of that year the meteors and the great planet *Uranus* were both at the point where their orbits intersect —an event which has not happened since. This raises a well founded suspicion that up to that year the meteors may have been a compact cluster travelling inwards towards the Sun; that in that year they stumbled on this great planet; and that it remained long enough in their vicinity to exercise such an influence over them as drew them out of their previous course and started them in the new orbits round the Sun, which they have since for nearly eighteen centuries pursued. If it acted in this way the planet would inevitably perturb the several members of the group a little differently, so that their new orbits would not be precisely the same. If, in consequence of this their periodic times vary from a week more to a week less than the mean periodic time (which mean is about thirty-three years and a fifth), just that extension of the group which we actually observe would have had time to develop in the fifty-three revolutions that have since taken place.

It is most desirable that everything that it is possible to do shall be done to test this remarkable theory. It seems to be possible to test it, for, owing to the perturbation of their elliptic motion by the planets, the orbits of the meteors suffer an apsidal shift which is easily observed, and which, in fact, retards the date on which the great meteoric showers take place by a considerable amount every century. This is almost wholly owing to the attraction of the great planets *Jupiter* and *Saturn*. *Uranus*

* There is, however, one notable exception. We have reason to suspect that the comet is one of the bodies whose motion was perturbed by the Earth. Accurate observations of the comet should determine whether this is so; and if it prove to be the case, it should be possible further to determine when the catastrophe occurred, by tracing back the comet's course and the Earth's till we come to a time when they were near to one another.

produces a perceptible but trifling effect, and the influence of the Earth and the other planets is insensible. Now it so happens that the periodic time of the meteors is related in a very remarkable way to those of *Jupiter* and *Saturn*, being nearly nine-eighths of the periodic time of *Saturn*, and still more nearly fourteen-fifths of the periodic time of *Jupiter*. Accordingly, in the fifty-three revolutions of the meteors which have taken place since A.D. 126, *Saturn* and they have six times repeated somewhat similar cycles of relative positions, each, moreover, *of a very special character* ; and *Jupiter* and they have ten times repeated almost exactly the same cycle of relative positions. Now, where simple numerical relations of this kind subsist, the situation of a meteor along the orbit—viz. whether it is near the head or the tail of the meteoric stream, still more if it be an outlying meteor in front or behind —is likely to have an appreciable effect on the apsidal shift which its orbit suffers. It is, therefore, of great importance to determine whether any such differences between the apsidal shift of meteors variously situated can be observed, in order that the observed amounts may be compared with those calculated on the supposition that Le Verrier's hypothesis is true. If the calculated and observed amounts accord, Le Verrier's hypothesis will be proved ; if they do not accord, it will be disproved : in either case we shall know more about the history of the meteors than we do now.

Hence the great importance of this year commencing the task of determining the exact radiant points of different portions of the swarm, and the approximate times of their apparition in our atmosphere, so as to furnish to mathematicians the requisite data for their calculations. In this work it is obvious that eye observations should, as far as possible, be replaced by photographs.*

Galactic Longitude and Latitude of Poles of Binary-Star Orbits.
By Alice Everett.

The data upon which the accompanying table is founded are not satisfactory. In the case of a very few stars there seems little doubt that the orbit determined is substantially correct, and in the case of a few more the elements obtained by different computers show some agreement. These will be recognised in the list by those familiar with the subject. But the greater number of orbits computed seem to be very uncertain.

From the results, such as they are, it does not seem that any decided tendency on the part of the poles of the orbits to favour any special region of the sphere can reasonably be deduced. (See summary appended to tables.)

* A popular account of the discoveries made in connection with the last visit of the November meteors will be found in the Journal of the Royal Dublin Society of 1869 April 3, and in the Proceedings of the Royal Institution of 1879 February 14; and appended to it there is a list of the original memoirs in reference to the advances which were then made.

The stars considered were the following :—

(1) Those for which I could find orbits published since 1890.

(2) Those of period less than 100 years, the orbits of which have not since been re-computed (fifteen in number), given in Mr. Gore's "Catalogue of Binary Stars for which Orbits have been computed" (published in 1890).

The latest orbit has been taken for each star when more than one exists. A few more obviously doubtful or fallacious orbits have been omitted.

I have collected the elements of 73 orbits of 45 stars published since 1890.

The computed galactic longitudes and latitudes of the poles of the orbits are given in the final columns of the table. There are two alternative results for each pole, corresponding to the two possible positions, equally inclined to the line of sight, for the plane of the orbit. The pole whose latitude is the lesser is placed first.

The R.A.'s and Decl.'s of the poles are shown in preceding columns, but here the result is given first for the case where i, the inclination, is assumed positive ; second, where it is assumed negative. Hence the pole entered first in these columns is not necessarily that entered first in the columns containing the galactic coordinates.

The position assumed for the northern pole of the Milky Way was R.A. 190° 31′, Decl. +27° 16′ (1890), as according to Gould, which gives 62° 7′ as the inclination of the central line to the equator and $18^h\ 42^m = 280°\ 31'$ as the R.A. of the ascending node, from which the galactic longitudes are reckoned.

Not knowing that formulæ for finding the R.A. and Decl. of the pole of an orbit had been published (Mr. Marth has since referred me to Encke's article in the *Berliner Astr. Jahrbuch* 1832), I deduced them for myself. A list of R.A.'s and Decl.'s of poles of binary-star orbits was published by Dr. Doberck in 1882 (*Ast. Nach.* 2433), and a sequel to it by Mr. Gore in 1888 in a paper on "The Position of the Planes of Binary Stars" (*Jour. Liv.* A.S. vol. vi.), of the existence of which I was not aware till I had finished my calculations. But nearly all the orbits here considered have been computed in more recent years.

The results were checked by graphic means with the help of a globe, the graphic results generally agreeing with the theoretical to within a degree or two. A globe is, of course, useful in all spherical trigonometrical work in clearing the ideas and showing at sight in what quadrant the angle corresponding to a given trigonometrical function should lie. I bought mine unmounted from the maker in its original simple state before the map and outer coating had been applied, and drew the necessary circles and points of reference upon it. Pencil marks can be written and rubbed out quite well upon the smooth white surface, or sponged off when many accumulate. In default of a spherical sector, spherical angles can be measured as arcs along great circles polar to their apices.

No.	Stars in order of Right Ascension.	R.A. and Decl of star 1890. R.A.	Decl.	Galactic Long. and Lat. of star. Long.	Lat.	Period in Years.	Computer.	Date of Publication
		h m s	° ′	°	°			
1.	Σ 3062	0 0 30	+57 49	84·5	− 4 5	104·6	See	1895
2.	Σ 2	0 3 15	+79 7	88·1	+16·5	166·2	Glasenapp	1892
3.	η Cassiop.	0 42 27	+57 14	90·1	− 5·5	195·8 208 1	See Lewis	1895 1894
4.	36 Androm.	0 49 5	+23 2	92·1	−39·7	137·5	Lewis	1891
5.	Σ 186	1 50 12	+ 1 18	122 6	−57·1	150·8	Glasenapp	1891
6.	γ Androm.	1 57 8	+41 48	104·7	−18·8	54·8	Burnham	1893
7.	Σ 228	2 7 0	+46 59	104·7	−13·3	88·7	Gore	1889
8.	20 Persei	2 46 46	+37 46	115·6	−18·7	20·8	Glasenapp Burnham	1893
9.	40 Eridani	4 10 13	− 7 49	168·5	−37 2	176 2	Glasenapp	1896
10.	OΣ 82	4 16 29	+14 48	147·8	−23·1	158·4	Glasenapp	1893
11.	β 883 = Lal. 9091	4 45 6	+10 53	155·7	−19·9	16·4	Glasenapp	1892
12.	OΣ 149	6 29 34	+29 22	152·3	+10·5	85·9	Glasenapp	1889
13.	Sirius	6 40 18	−16 34	194·6	− 7·9	51·1	Zwiers	1895
14.	Σ 1037	7 5 57	+27 26	157·4	+17·0	15·0	Mädler	?
15.	9 Argûs	7 46 41	−13 36	199·6	+ 7·6	22·0	See	1895
16.	ζ Cancri	8 5 54	+17 59	172·4	+26·4	59·1	Seeliger	1888
17.	Σ 3121	9 11 22	+29 2	164·8	+43·9	34·0	See	1895
18.	ω Leonis	9 22 34	+ 9 32	190·8	+39·9	116 2	See	1895
19.	φ Ursæ Maj.	9 44 37	+54 35	127·2	+47·9	91·9	Glasenapp	1892
20.	8 Sextantis	9 47 4	− 7 35	213·0	+35·2	93·9	Glasenapp	1892
21.	ξ Ursæ Maj.	11 12 19	+32 9	160·5	+70 0	60·0	See	1895
22.	ι Leonis	11 18 11	+11 8	215·3	+64·5	178 6	Everett	1895
23.	OΣ 234	11 24 53	+41 55	132·1	+68·5	63·5	Gore	1886
24.	OΣ 235	11 26 6	+61 41	105·0	+53·3	94·4	Doberck	1879
25.	γ Centauri	12 35 27	−48 21	268·9	+14 4	88·0	See	1896
26.	γ Virginis	12 36 5	− 0 58	266 8	+61·7	194·0	See	1895
27.	42 Comæ Beren.	13 4 38	+18 7	307·4	+81·8	25·7	O. Struve & Doubiago	1875
28.	OΣ 269	13 27 53	+35 29	42·9	+77·3	47·7	Gore	1892
29.	β 612 = B.A.C. 4559	13 34 10	+11 18	310·0	+69·9	30·0	Glasenapp	1892
30.	Σ 1785	13 44 6	+27 32	4·7	+76·2	125·5	Gore	1893
31.	α Centauri	14 32 10	−60 23	283·2	− 0·5	81·2	Roberts—See	1895
32.	Σ 1879	14 40 51	+10 8	334·2	+57·2	146·9	Lewis	1895
33.	OΣ 285	14 41 22	+42 50	40 6	+61·3	76·7	See	1895
34.	ξ Boötis	14 46 19	+19 33	351·6	+60 6	128 0	See	1895
35.	μ^2 Boötis	15 20 20	+37 46	27·8	+55·3	219·4	See	1895
36.	η Cor. Bor.	15 18 40	+30 41	15·2	+55·8	41·6	Doberck	1880
37.	OΣ 298	15 32 3	+40 12	31·5	+52·8	56·7	Celoria	1888
38.	γ Cor. Bor.	15 38 7	+26 39	9·5	+51·0	73·0	See	1896
39.	ξ Scorpii	15 58 19	−11 4	327 9	+28·9	95·9	Doberck	1877
40.	σ Cor. Bor.	16 10 33	+34 8	22·2	+45 2	370·0	See	1896
41.	ζ Herculis	16 37 8	+31 48	19·8	+39·2	35·0	See	1895
42.	β 416 = B.A.C. 5825	17 11 28	−34 52	319·2	+ 1·1	33·0	See	1896
43.	Σ 2173	17 24 45	− 0 59	350·0	+16·7	46·0	See	1895
44.	μ^1 Herculis	17 42 7	+27 47	19·9	+24·6	48·7	Celoria	1890
45.	70 Ophiuchi	17 59 54	+ 2 32	357·4	+10·5	88·4	Schur	1894
46.	99 Herculis	18 2 54	+30 33	24·4	+21·3	54·5	See	1896
47.	ζ Sagitt.	18 55 37	−30 2	334·0	−15·9	18·9	See	1895
48.	γ Cor. Aust.	18 58 59	−37 13	327·2	−19·2	152·7	See	1895
49.	Σ 2525	19 22 4	+27 6	28·5	+ 4·1	138·5	Gore	1892
50.	β Delphini	20 32 33	+14 13	26·3	−16·7	27·7	See	1895
51.	4 Aquarii	20 45 30	− 6 2	9·3	−30·1	126·7	See	1895
52.	δ Equulei	21 9 7	+ 9 34	27·9	−26·7	11·45	See	1895
53.	τ Cygni	21 10 24	+37 35	50·3	− 8·4	36·5	Burnham	1894
54.	κ Pegasi	21 39 40	+25 8	45·9	−21·6	11·42	See	1895
55.	85 Pegasi	23 56 25	+26 30	77·5	−35·1	24·0	See	1895

A.N. = *Astronomische Nachrichten*; M.N. = *Monthly Notices, R.A.S.*,

Source.	R.A. and Decl. of N. Pole of Orbit. I. Inclination positive. R.A.	Decl.	II. Inclination negative. R.A.	Decl.	Galactic Long. and Lat. of Pole of Orbit. A. Pole of lesser Lat. Long.	Lat.	B. Pole of greater Lat. Long.	Lat.	No
	°	°	°	°					
A.N. 3292	265	62	30	20	58	+31	294	+39	1.
A.N. 3145	112	24	299	15	202	9	162	20	2.
A.J. 355	274	60	42	18					
M.N. vol. lv. 19	270	59	42	16	59	28	309	37	3.
M.N. vol. li. 462	54	55	169	15	114	0	207	66	4.
A.J. 246	326	52	267	51	244	2	45	29	5.
M.N. vol. liv. 119	169	53	182	33	116	60	142	81	6.
Gore's Cat.	224	62	217	24	66	49	358	66	7.
A. and A. vol. xii. May, June, and Lick Obs. vol. ii.	149	47	177	22	138	52	198	76	8.
A.N. 3357	126	29	170	35	162	34	150	71	9.
A.N. 3193	48	57	254	28	290	1	17	35	10.
A.N. 3119	59	37	261	16	308	11	6	24	11.
Gore's Cat.	132	45	73	8	340	20	143	41	12.
A.N. 3336	65	12	325	37	235	12	331	24	13.
Gore's Cat.	186	30	227	9	338	51	150	85	14.
A.N. 3297	129	64	194	84	90	33	119	37	15.
Gore's Cat.	119	29	123	7	184	23	160	28	16.
A.J. 349	48	32	20	16	304	21	283	46	17.
A.N. 3311	205	34	266	24	17	23	32	76	18.
A.N. 3119	203	49	103	36	148	18	69	67	19.
A.N. 3119	165	18	306	33	220	4	196	65	20.
A.N. 3323	243	81	338	23	236	31	81	33	21.
M.N. vol. lv. 440	102	41	43	30	143	19	301	25	22.
Gore's Cat.	248	65	327	0	63	38	206	40	23.
Gore's Cat.	341	58	166	2	255	1	223	55	24.
A.N. 3339	300	18	83	23	331	4	205	9	25.
A.J. 352	168	22	30	24	292	35	188	69	26.
Gore's Cat.	103	10	103	10	172	7	172	7	27.
M.N. vol. lii. 550	82	45	70	34	316	7	132	7	28.
A. and A. 466	7	5	222	26	263	58	5	62	29.
M.N. vol. liii. 333	243	46	181	2	40	45	249	63	30.
A.N. 3175 M.N. vol. liv. 102	155	3	145	22	210	48	178	48	31.
M.N. lvi. 33	159	62	78	49	128	7	112	49	32.
A.J. 356	155	70	239	4	342	39	106	43	33.
A.N. 3334	273	4	166	20	0	9	193	66	34.
A.N. 3309	284	36	188	17	35	13	257	79	35.
Gore's Cat.	157	35	101	4	177	2	156	60	36.
Gore's Cat.	161	17	303	14	203	13	194	61	37.
A.J. 376	5	62	21	50	268	0	277	12	38.
Gore's Cat.	173	7	130	15	179	33	227	64	39.
A.N. 3339	181	44	282	4	4	0	112	72	40.
A.J. 357	183	47	108	5	179	9	104	69	41.
A.J. 372	108	10	30	48	175	11	283	16	42.
A.N. 3311	340	26	1	24	239	30	259	36	43.
Gore's Cat.	175	66	114	31	156	25	100	50	44.
A.N. 3231	314	50	60	46	57	2	296	9	45.
A.J. 366	271	31	271	31	24	21	24	21	46.
A.J. 355	261	34	211	70	25	30	80	46	47.
A.N. 3323	95	4	131	68	353	3	114	37	48.
M.N. vol. liii. 44	245	77	121	26	163	29	77	34	49.
A.J. 357	245	10	9	3	353	36	268	59	50.
A.J. 341	20	0	63	5	336	31	289	61	51.
A.N. 3290	235	23	212	20	5	50	343	69	52.
Lick Obs. vol. ii.	17	36	271	15	9	15	276	27	53.
A.N. 3285	83	60	105	48	120	16	137	22	54.
A.N. 3339	63	66	155	24	109	12	178	58	55.

A.J. = *Astronomical Journal*, A. and A. = *Astronomy and Astro-Physics*.

Summary.

If the sphere be divided into equal-surface zones of galactic latitude, the distribution of the poles of the orbits according to the above results would be as follows :

Zone of Galactic Latitude.	Number of Poles in each Zone. A. When, for each Star, the orbit corresponding to the pole of lesser latitude is taken.	B. When, for each Star, the orbit corresponding to the pole of greater latitude is taken.	Mean of numbers in two preceding columns. $\frac{A+B}{2}$.
0°–11°	19	4	11½
12–23	13	5	9
24–37	13	11	12
37–53	8	11	9½
53–90	2	24	13

If we consider only stars lying not far from the Milky Way, say, for example, those whose galactic latitude is under 40°, then these numbers become :

Zone of Galactic Latitude.	Number of Poles in each Zone. A.	B.	Mean of numbers in two preceding columns. $\frac{A+B}{2}$.
0°–11°	10	2	6
12–23	8	4	6
24–37	11	8	9½
37–53	5	7	6
53–90	1	14	7½

Kgl. Astrophysikalisches Observatorium zu Potsdam : 1896 *June.*

On the Corrections to the Right Ascensions of Stars derived from Observations of the Sun made at Greenwich during the years 1836–1895. By W. G. Thackeray.

If a comparison be made between the values of the proper motions in right ascension for the fundamental stars as given by Professor Newcomb in his standard right ascensions, and by Dr. Auwers from his re-reduction of Bradley's observations, it will be found that Professor Newcomb's proper motions are on the average nearly $^{s}\cdot001$ larger than those given by Dr. Auwers. It would therefore seem that the epoch correction of one or other

of these systems of right ascensions must be in error, as they both used Struve's precession.

Professor Newcomb in *A. J.* No. 359, in a paper "On the Value of the Precessional Constant," has shown that, if Δa be assumed to be the correction to the centennial motion of the equinox in R.A. as determined by Auwers Bradley in 1755 and by Pulkova in 1855, a comparison with 97 time stars of the American ephemeris, taking as the basis of comparison his own system of right ascensions as found in the Catalogue of vol. i. of the *Astronomical Papers*, and reproduced in the American ephemeris for the years 1881–1899 gives—

$$\Delta a = + 0^{s}.120.$$

Now the Auwers-Bradley's proper motions and the Struve-Peters's value of precession and the places of the stars in the Greenwich Five-Year Catalogue, 1890, constitute the basis of the present Greenwich clock-star lists, and this paper discusses the adoption of this system as a standard and deduces the correction given by the observations of the Sun for the years 1836–1895, with the result that referred the centennial variation $= +0^{s}.132$ to 1880.

From 1836–1852 the clock-star list contained 62 stars, which was increased by the addition of some 90 stars in 1853 to about 150 stars. Further small additions were made from time to time, till in 1859 the list comprised some 190 stars, and at the present time the number of stars has increased to 210.

In order to obtain the necessary correction to the adopted clock-star list places as given in the Introductions to the several volumes of Greenwich observations, the Five-Year Catalogue place of each clock-star has been reduced with Auwers' proper motions and Struve's precession for every year from 1836–1848 and compared with the adopted clock-star place for the year, and the corresponding corrections thus found have been multiplied by weights proportional to the number of observations of each star made in each year, and the sum of all these products divided by the number of the weights has been assumed to be the general correction to the clock-star system in use for each of these years, and therefore the general corrections to the observations of the Sun for that year.

After the year 1848, when the system of making the clock-star list depend on a definite catalogue place was inaugurated, it has been assumed that the mean correction given by all the clock-stars by direct comparison with the Five-Year Catalogue, 1890, reduced to the various epochs of the different catalogues upon which the different clock-star lists depend, constituted the proper correction to be applied to the year's observations as long as the same Catalogue was in use. The legitimacy of this assumption has been verified by finding the actual corrections to the clock errors on each day when the Sun was observed during

the four years 1836, 1841, 1843, and 1846 (chosen at random), deducing the actual correction to the tabular right ascension and the ecliptic north polar distance, and inserting the corrections in the corresponding equations of the discussion of the position of the ecliptic as given in the volume of Greenwich observations.

The following table gives the corrections to the tabular errors of right ascension of the Sun and the corresponding corrections to the ecliptic north polar distance for each month of the four above-named years with the weights used in the equations for the discussion of the position of the ecliptic.

TABLE I.

Corrections to tabular errors of the Sun in right ascension and ecliptic north polar distance to refer the observation of the Sun to a standard system of clock-stars based on the Greenwich Five Year Catalogue, 1890, *Auwers-Bradley's proper motions and Struve-Peters precession.*

Month.	1836			1841			1843			1846		
	Corr. to Tab. Error of Sun in R.A.	Corr. to E.N.P.D.	Weight.	Corr. to Tab. Error of Sun in R.A.	Corr. to E.N.P.D.	Weight.	Corr. to Tab. Error of Sun in R.A.	Corr. to E.N.P.D.	Weight.	Corr. to Tab. Error of Sun in R.A.	Corr. to E.N.P.D.	Weight.
	s	"		s	"		s	"		s	"	
Jan.	+·036	+·106	12	·000	·000	7	−·095	−·273	7	−·047	−·114	8
Feb.	+·042	+·194	12	+·007	+·029	8	−·082	−·448	11	−·058	−·288	9
Mar.	+·088	+·531	6	+·016	+·096	13	−·052	−·310	13	−·028	−·179	11
Apr.	+·066	+·367	5	+·030	+·159	9	−·072	−·366	12	−·021	−·107	8
May	+·021	+·067	14	+·003	+·010	10	−·109	−·317	10	−·065	−·232	6
June	+·012	+·003	11	+·018	+·014	9	−·073	+·036	9	−·060	−·057	13
July	+·013	−·021	12	+·013	−·040	6	−·086	+·248	7	−·067	+·193	12
Aug.	−·011	+·046	13	·000	·000	12	−·096	+·455	10	−·075	+·425	9
Sept.	−·003	·000	5	+·005	−·030	10	−·103	+·604	14	−·083	+·477	7
Oct.	+·043	−·218	9	−·013	+·063	9	−·096	+·537	15	−·059	+·333	6
Nov.	−·008	+·037	14	−·002	+·007	9	−·100	+·380	9	−·062	+·211	10
Dec.	+·014	−·068	7	−·010	+·005	10	−·108	+·179	7	−·075	+·024	11

Let Δx, Δy, be the corrections to the values of x and y previously deduced, then the corresponding equations from the discussions of the position of the ecliptic in the several volumes of Greenwich observations give for—

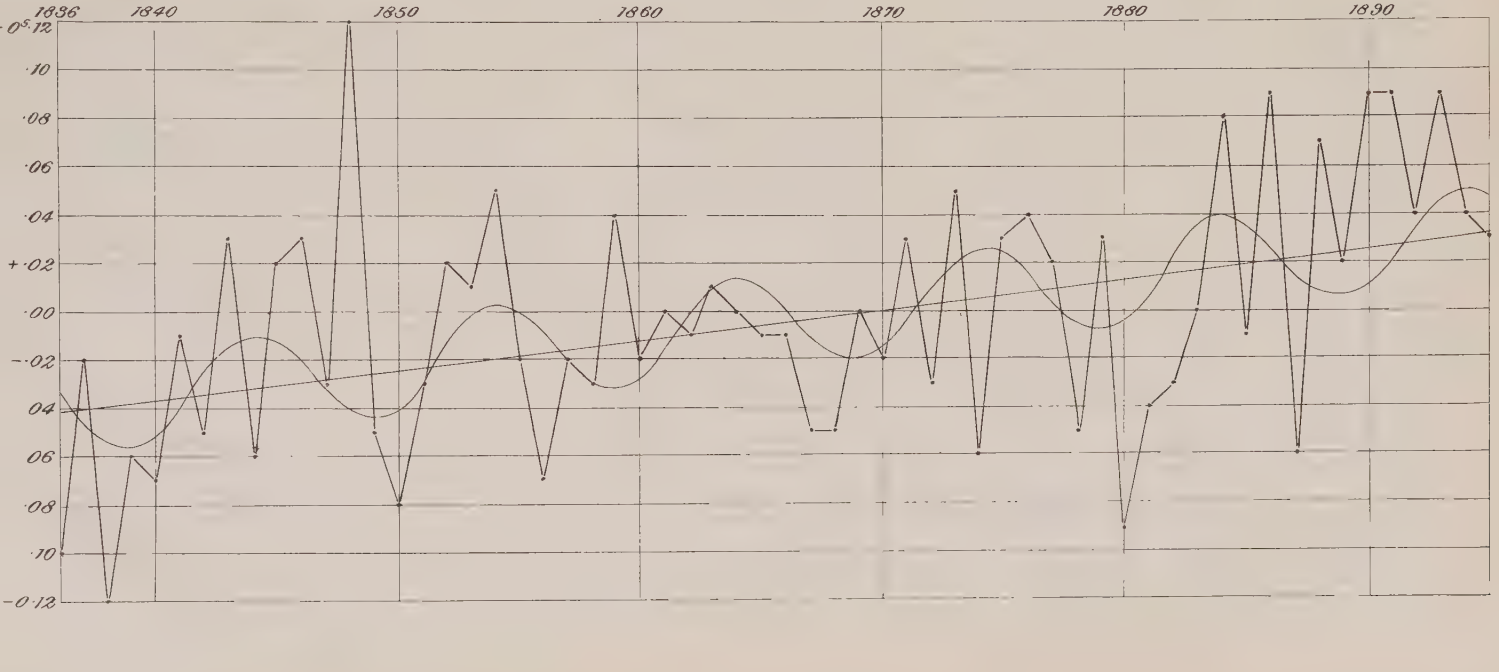
1836 $\left\{\begin{array}{l} 71{\cdot}12\,\Delta x + 7{\cdot}64\,\Delta y = +10{\cdot}726 \\ 9{\cdot}66\,\Delta x - 85{\cdot}26\,\Delta y = +\ 2{\cdot}143 \end{array}\right\}$ whence $\Delta x = +0{\cdot}15$

1841 $\left\{\begin{array}{l} 73{\cdot}02\,\Delta x + 14{\cdot}20\,\Delta y = +\ 2{\cdot}997 \\ 14{\cdot}31\,\Delta x - 69{\cdot}28\,\Delta y = +\ 1{\cdot}043 \end{array}\right\}$ whence $\Delta x = +0{\cdot}04$

1843 $\left\{\begin{array}{l} 88{\cdot}33\,\Delta x + 18\,07\,\Delta y = -45{\cdot}797 \\ 14{\cdot}77\,\Delta x - 67{\cdot}81\,\Delta y = -\ 3{\cdot}845 \end{array}\right\}$ whence $\Delta x = -0{\cdot}49$

1846 $\left\{\begin{array}{l} 66{\cdot}26\,\Delta x + 14{\cdot}13\,\Delta y = -22{\cdot}314 \\ 17{\cdot}16\,\Delta x - 71{\cdot}12\,\Delta y = -\ 7{\cdot}591 \end{array}\right\}$ when $\Delta x = -0{\cdot}33$.

Corrections to Right Ascensions of Clock Stars referred to a uniform system from observations of the Sun, 1836–1895.



Dividing each of these quantities by 15 sin 23° 28′ we get the following corrections to the right ascension of the stars :

	Years 1836.	1841.	1843.	1846.
(1)	+ˢ·025	+ˢ·007	−ˢ·081	−ˢ·055

the values previously adopted by weighting the corrections for each star proportionally to the number of observations made in each year was

(2)	+ˢ·020	+ˢ·008	−ˢ·076	−ˢ·060

by taking the simple mean of all the corrections to all the clock-stars, and virtually assuming that the clock errors for the obser vations of the Sun are well distributed over the whole clock-star list in the course of the year, these quantities would be

(3)	+ˢ·026	+ˢ·012	−ˢ·079	−ˢ·060

It would thus appear that the observations of the clock stars upon which the Sun observations in the course of a year depend seem to be well distributed over the whole list, or that the errors of the individual clock errors are of an accidental character, and in the main well determined. In any case it does not appear that the method (2) or (3) of finding the correction to the adopted results of the Sun observations can introduce any sensible error, especially as we are adopting in the final results only two places of decimals, and also considering the large accidental errors evidently existing in the quantities themselves.

The chronograph was brought into use during the year 1854.

Table II.

Table of adopted corrections to reduce the adopted Clock-Star Lists, 1836–1895, to the Right Ascensions of the Five-Year Catalogue, 1890.

Year.	Corr. s	Year.	Corr. s
1836	−·020	1846	+·060
1837	−·013	1847	+·078
1838	−·015	1848	+·078
1839	−·001	1849–1855	+·011
1840	−·000	1856–1861	+·002
1841	−·008	1862–1869	+·005
1842	−·001	1870–1877	+·013
1843	+·076	1878–1888	·000
1844	+·083	1889–1895	·000
1845	+·089	...	...

These quantities with sign changed are directly applicable (see *M. N.* liv. p. 417) to the quantities given in the introductions to the several catalogues as corrections to the right ascensions of clock-stars from discussions of the position of the ecliptic, and these quantities thus corrected are given in the following table.

For the years 1836–1863 the places of the Sun were computed from Carlini's Tables; from 1865–1895 from those of Le Verrier :—

TABLE III.

Table of corrections to a system of Right Ascensions of Clock-Stars depending on the position of the Five-Year Catalogue, 1890, from observations of the Sun for the years 1836–1895.

Year.	Corr. s	Year.	Corr. s	Year.	Corr. s	Year.	Corr. s
1836	−0·11	1851	−0 03	1866	−0·01	1881	−0·04
1837	− ·03	1852	+ ·02	1867	− ·05	1882	− ·03
1838	− ·12	1853	+ ·01	1868	− ·05	1883	·00
1839	− ·07	1854	+ ·05	1869	·00	1884	+ ·08
1840	− ·09	1855	− ·02	1870	− ·02	1885	− ·01
1841	− ·01	1856	− ·07	1871	+ ·03	1886	+ ·09
1842	− ·05	1857	− ·02	1872	− ·03	1887	− ·06
1843	+ ·03	1858	− ·03	1873	+ ·05	1888	+ ·07
1844	− ·07	1859	+ ·04	1874	− ·06	1889	+ ·02
1845	+ ·00	1860	− ·02	1875	+ ·03	1890	+ ·09
1846	+ ·03	1861	·00	1876	+ ·04	1891	+ ·09
1847	− ·04	1862	− ·01	1877	+ ·02	1892	+ ·04
1848	+ ·11	1863	+ ·01	1878	− ·05	1893	+ ·09
1849	− ·05	1864	·00	1879	+ ·03	1894	+ ·04
1850	− ·08	1865	− ·01	1880	− ·09	1895	+ ·03

The mean of these corrections is

$$-0^{s}\cdot005 \pm 0\cdot0047,$$

and the probable error of a single determination is

$$\pm 0^{s}\cdot035.$$

The true value of this correction being of the form

$$x + y\mathrm{T} = \text{annual correction},$$

where T is the fraction of a century from the adopted epoch 1880, the solution of the sixty resulting equations by the method of least squares gives the following normal equations :

$$60\,x - 8\cdot70\,y = -0\cdot29^{s}$$
$$-8\cdot70\,x + 3\cdot07\,y = +0\cdot30,$$

whence

$$x = +0^{s}\cdot015 \qquad y = +0^{s}\cdot132.$$

The quantities in Table III., arranged in series of ten years, show as follows :—

1836.	1837.	1838.	1839.	1840.	1841.	1842.	1843.	1844.	1845.
$-^{s}\cdot005$	$-^{s}\cdot030$	$-^{s}\cdot012$*	$-^{s}\cdot005$	$-^{s}\cdot035$	$+^{s}\cdot007$	$-^{s}\cdot008$	$+^{s}\cdot030$	$+^{s}\cdot008$	$+\cdot003$

* Excluding the result for 1848, which is somewhat anomalous, the result would be $-^{s}\cdot030$.

This apparent period may be purely accidental, but a correction may be fairly represented by the expression

$$+0^{s}\cdot02 \cos (T-1844)\, 36^{\circ}.$$

As the accidental errors existing in the correction to the right ascensions of the clock-stars derived from the discussions of the position of the ecliptic appear to be large, it would seem inexpedient to refer catalogues extending over a short period of time directly to the corresponding observations of the Sun in preference to basing the right ascensions on a well-determined system of clock-stars.

As an instance of the uncertainty of the actual value of this correction, the 1840 and 1845 Greenwich Catalogues afford instructive examples, for in the Introduction it is shown that after the clock-stars have been all reduced to the same system, the correction for epoch for the years 1836–41 is $-0^{s}\cdot110$, and for the years 1842–48 is $-0^{s}\cdot043$.

On the Proper Motion of B.D.+25°, No. 2874.

By Walter W. Bryant.

This star is a wide companion of *c Boötis*, which appears in most catalogues with a well-determined P.M. of $+0^{s}\cdot0116$ in R.A. and $+0''\cdot191$ in N.P.D.

Baron d'Engelhardt measured this among his Bradley's wide pairs, and from his observations, made in 1887 and 1889, suspected that the faint star had also a P.M. Finding a meridian observation of the star in B.D. (vol. vi.), which confirmed this view, he wrote to Professor Schönfeld, who assured him that he had no reason to suspect the accuracy of the Bonn observation.

Combining this with his own observations, the Baron obtained for this star a P.M. of $-0^{s}\cdot0642$ in R.A. and $-0''\cdot408$ in N.P.D. He notes the magnitude as 9·5 (fainter than 9·2 given in B.D. But being apparently desirous to risk nothing on the accuracy of a single meridian observation, he continued his measures in 1893 and 1895, and from his own sets (11 measures in all) he obtained a revised value of P.M. in R.A. $-0^{s}\cdot0666$, and in N.P.D. $-0''\cdot631$.

It will be noted that the agreement in R.A. is fair, but in N.P.D. very poor.

After a fruitless search through many catalogues and volumes of observations I discovered a single observation of the star made at Vienna in 1836, over two wires only in R.A. and without any N.P.D., which, by differentiating from the observation of *c Boötis* taken just before it, gave a difference of R.A. of $18^s{\cdot}8 \pm 0^s{\cdot}2$, from which the R.A. of the star in question is half a second too great compared with the later observations.

On account of the suspected large P.M. the star was entered in the Greenwich Working Catalogue, and three observations have been secured this year, giving the place of the star.

	R.A. 1896·0.	N.P.D. 1896·0.
Apr. 22	15 2 57·56	64° 40′ 41″·13
May 11	15 2 57·53	64 40 42·93
14	15 2 57·43	64 40 43·43

(reduced without P.M. to 1896·0).

Combined with the Bonn observation these give—

P.M. $-0^s{\cdot}0632$ in R.A. and $-0''{\cdot}479$ in N.P.D.,

thus confirming the smaller values obtained before from the Bonn observation, and perhaps casting doubts on its accuracy.

But though the accuracy of single meridian observations may be very well despised there will be noted a peculiar run in the three Greenwich observations. Now a star with a P.M. amounting to over $1''$ of arc may be very readily suspected of having an appreciable parallax.

The above star is in opposition on May 8, so that if it have any parallax there would be a great difference between observations a month before and a month after this date, amounting in R.A. to the whole of the semi-annual parallax.

Also being some 42° north of the ecliptic, its parallax in N.P.D. will make that element a minimum about opposition.

So the Greenwich R.A.'s as they diminish through opposition give some evidence of parallax in R.A., while the N.P.D.'s, though they do not indicate any minimum, yet are increasing after opposition, as would be expected on the above hypothesis.

Again, Baron d'Engelhardt's observations, which indicate a smaller R.A. than the Greenwich ones, are none of them earlier than the end of June, when the parallax in R.A. would tend to make it smaller, while the progressive change due to it is then so small that it would easily escape notice. In N.P.D. it would be noticeable at that time (though of course never so much so as in the R.A. before and after opposition), and, curiously enough, Baron d'Engelhardt's N.P.D. observations do not give so near an agreement as his R.A.'s, the observations of 1889, which were

made in July, standing out in both elements from those of the other three years, made towards the end of June.

It seems quite possible, therefore, that this star will repay observations made east of the meridian in the winter, and a very few measures would suffice to show whether the investigation were really worth pursuing.

The distance of the star from *c Boötis* is roughly $13\frac{1}{2}$ seconds following and nearly 3′ north.

Occultations of certain Stars in Præsepe by the Moon on 1896 *October* 1, *visible at Greenwich.*

(*Communicated by the Superintendent of the "Nautical Almanac."*)

The following table gives the particulars of the Occultations of the brighter stars in Præsepe on October 1 next, as visible at Greenwich. The places of the stars have been taken from Schur's *Die Oerter der hellern Sterne der Præsepe.*

If it should be found possible to observe any fainter stars in Schur's list than those included in the following table, the circumstances of their occultation can easily be deduced graphically, with sufficient accuracy for the purpose of identification, from the data of the table.

The time of Sun rise at Greenwich is $18^h\ 4^m$.

Occultations visible at Greenwich, 1896 *October* 1.

The Angles are reckoned from the North Point and Vertex of the Moon's limb towards the East.

Star's Name	Schur's No.	Mag. (B.D.)	Disappearance. G.M.T.	North	Vertex.	Reappearance. G.M.T.	North	Vertex.
			h m	°	°	h m	°	°
38 Cancri	No. 15	7·0	16 13	79	118	17 14	321	355
BD + 20° 2150	No. 17	7·2	16 24	125	165	17 32	273	305
BD + 20° 2166	No. 27	7·3	16 34	91	129	17 41	310	341
ϵ Cancri	No. 31	7·2	16 40	115	153	17 52	286	315
42 Cancri	No. 34	7·1	16 46	73	110	17 44	329	359
BD + 20° 2175	No. 37	7·7	16 53	99	136	18 4	303	330
BD + 19° 2069	No. 26	7·0	17 0	163	199	17 43	237	268
BD + 20° 2185	No. 43	7·5	17 46*	22	53			

Nautical Almanac Office,
1896 *June* 6.

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* A near approach.

Note on a Possible Eclipse of Jupiter's Second Satellite by the Shadow of the Third 1896 March 30. By A. C. D. Crommelin.

The April number of the "Journal of the Astronomical Society of Wales" contains the following communication from Mr. Fred Jackson, of Stoke-on-Trent: "A curious extinction of Satellite II. took place for a few seconds March 30, about $9^h\ 10^m$. The other satellites appeared as usual, but II. was very indistinct before its strange disappearance, and of a dirty yellow colour." This description suggested an eclipse by the shadow of one of the other satellites, and on examination I found that the shadow of III. was in close proximity to II. at the time named. In reply to my request for further particulars, Mr. Jackson forwarded the following additional details, which he permits me to reproduce:—

"On March 30, about $9^h\ 20^m$ (the time $9^h\ 10^m$ given in the 'Journal of the Astronomical Society of Wales' is erroneous), observing with a 5-inch reflector, power 110, I noticed that Satellite II. was very faint and indistinct. It was very much smaller than the others, and required quite an effort to see it. I happened to turn from the telescope for a minute or so, and when I looked again I could not see the satellite for a few seconds, the other satellites being visible at the first glance. When I caught sight of II. again it was small and ill-defined, and appeared as though it was struggling through something. It grew brighter shortly afterwards, but not as bright as I have seen it on other occasions, even in the immediate vicinity of the primary. I left off observing Jupiter shortly afterwards, and did not see the occultation of II., which took place at $9^h\ 57^m$. The night was not a very favourable one for observation, only first and second magnitude stars being visible to the naked eye. The details on the surface of Jupiter were not sufficiently well-defined to permit of making a drawing."

Mr. Jackson states that he has been observing for some years, and has had a fair amount of experience.

Mr. Marth kindly communicated to me the following particulars of the heliocentric positions of the satellites:—

True time.	Time corrected for light passage to Earth 41 mins.	Relative heliocentric positions of II. and III.	
		$x_2 - x_3$.	$y_2 - y_3$.
d h m	h m	"	"
Mar. 30 8 20	9 1	− 9·89	+ 3·60
8 50	9 31	+ 1·20	+ 3·55
9 20	10 1	+ 12·36	+ 3 50

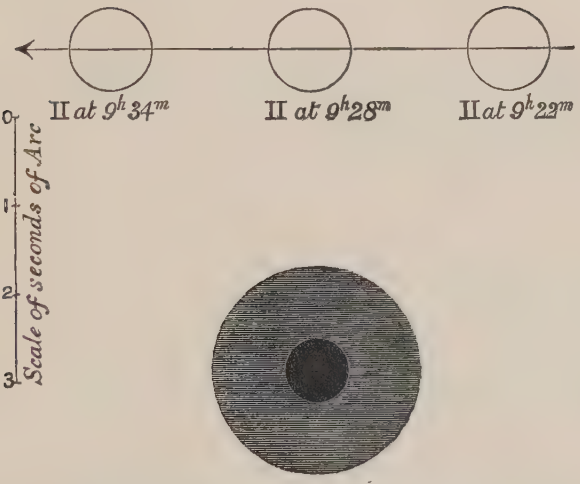

Diagram illustrating the Conjunction of Satellite II with the Shadow of III.

The diagram shows the projection of the shadow of III. on a plane through II., normal to the radius vector, and the position of II. relatively to the shadow at $9^h\ 22^m$, $9^h\ 28^m$, and $9^h\ 34^m$. (These times have been corrected for the time of light passage to the Earth.) The assumed diameters of the satellites are III. 3,560 miles, and II. 2,200 miles. It will be seen that an error of $2''$ in the difference of the latitudes of the satellites, as given by the Tables, would suffice to bring II. partially within the penumbra of III. Such an error is larger than we should expect, but perhaps not wholly inadmissible. I am, however, by no means confident that an eclipse actually occurred ; though, if not, the almost perfect agreement in time between this observation and conjunction with the shadow would be a curious coincidence. But the possibility of such a rare phenomenon having taken place makes it advisable to call attention to the above observation. According to Webb's "Celestial Objects for Common Telescopes" (4th edition, p. 164), there is one case on record of the eclipse of one satellite by the shadow of another ; the reference, however, is not given, and I have not been able to identify it. It is scarcely necessary to point out the great value of undoubted observations of the kind for determining the positions of the orbital planes of the satellites.

7 *Vanbrugh Park Road, Blackheath, S.E.* :
1896 *June* 10.

Measures of the Polar Diameter and of the Principal Belts, and of Two Dark Spots on Jupiter, and of the Satellites and their Shadows in Transit, made at Mr. Crossley's Observatory, Bermerside, Halifax, during the Apparition of 1895-96. By Joseph Gledhill.

Measures of the Polar Diameter.

The following results were obtained in four ways—A, by direct measures of the polar diameter of the apparent disc; B, by measures of the distances of satellites and shadows in transit from the poles of the disc; C, by measures of the distances of dark spots in transit from the two poles; D, by measures of the distances of the principal dark bands from the two poles.

In every case the micrometer was set to the computed position angle of *Jupiter's* equator as given by Mr. Marth.

The instrument used was the $9\frac{1}{3}$-inch Cooke equatorial refractor, with the parallel-wire micrometer by Simms, power 282.

A.

Under *a* is given the number of measures; under *b* the diameter; *m* measured, M Mr. Marth's value (both to the nearest tenth of a second); and under *c* the difference between *m* and M.

1896.	*a*	*b* *m*	*b* M	*c*		*a*	*b* *m*	*b* M	*c*
		″	″	″			″	″	″
Feb. 26	12	42·3	42·0	+0·3	Apr. 21	7	35·9	35·8	+0·1
Apr. 11	6	36·6	36·9	−0·3		6	36·1	35·8	+0·3
12	5	36·8	36·8	0·0	22	5	35·8	35·7	+0·1
13	8	36·4	36·7	−0·3	23	10	35·6	35·6	0·0
15	9	36·3	36·5	−0·2	24	5	35·6	35·5	+0·1
16	6	36·1	36·3	−0·2	26	6	34·9	35·3	−0·4
18	7	36·1	36·1	0·0	28	7	35·1	35·0	+0·1
20	5	36·0	35·9	+0·1	29	5	34·7	34·9	−0·2

The mean difference, regardless of sign, is nearly 0″·2.

B.

Feb. 23	39	43·0	42·2	+0·8	Apr. 3	2	38·1	37·8	+0·3
Mar. 18	9	40·0	39·7	+0·3	6	20	37·7	37·5	+0·2
19	2	39·5	39·6	−0·1	20	4	36·6	35·9	+0·7

The mean difference is 0″·4.

C.

1896.	*a*	*m*	*b* M	*c*		*a*	*m*	*b* M	*c*
		″	″	″			″	″	″
Feb. 26	3	43·0	42·0	+1·0	Mar. 18	2	39·7	39·7	0·0
	5	42·6	42·0	+0·6	23	6	38·9	39·2	−0·3
Mar. 9	6	41·4	40·8	+0·6	30	2	37·8	38·3	−0·5
15	4	39·4	40·1	−0·7	Apr. 11	4	36·6	36·9	−0·3

The mean difference is 0·″5.

D.

Mar. 9	4	40·2	40·8	−0·6	Apr. 18	6	36·4	36·1	+0·3
12	8	39·8	40·4	−0·6	20	6	36·4	35·9	+0·5
23	7	39·2	39·2	0 0	21	6	36·1	35·8	+0·3
30	3	38·3	38·3	0·0	22	6	35·9	35·7	+0·2
Apr. 3	4	37·8	37·8	0·0	23	6	35·6	35·6	0·0
9	6	37·5	37·1	+0·4	24	7	35·6	35·5	+0·1
10	5	37·6	37·0	+0·6	26	5	35·2	35·3	−0·1
11	5	36·6	36·9	−0·3	28	5	35·1	35·0	+0·1
12	6	36·5	36·8	−0·3	29	4	34·8	34·9	−0·1
13	6	37·1	36·7	+0·4	May 6	5	34·1	34·2	−0·1
15	6	36·6	36·5	+0·1					

The mean difference is 0·″24.

The computed values are for noon of each day, and are taken from Mr. Marth's ephemerides.

With regard to the atmospheric conditions prevailing when the above observations were made, it should be said that on no occasion were they really good, and rarely fairly good. It is only when mist or thin cloud prevails that steady images are obtained here.

Measures of the Position Angle of the North and South Edges of the Bright Equatorial Zone of Jupiter.

The strongly-marked double dark band just south of the equator was used in the earlier measures, and the narrow dark band just north of the equator in the later measures. After adjusting the parallel-wire micrometer on a bright and a fainter star near the meridian, the position webs were placed parallel to one of the belts just named.

In column *a* are given the means of from three to five measures; in column *b*, the position angle of the equator, from Mr. Marth's ephemerides. Power 282 was always used.

1896.	*a*	*b*		*a*	*b*
	°	°		°	°
Mar. 23	103·2	103·7	Apr. 18	104·2	104·0
Apr. 3	103·3	103·7	23	104·0	104·2
9	103·9	103·8	24	104·3	104·2
11	103·7	103·8	26	104·1	104·3
13	103·8	103·9	29	105·1	104·4
15	104·1	103·9	May 11	105·0	104·9
16	104·3	104·0			

These bands, therefore, are sensibly parallel to *Jupiter's* equator.

Measures of the Position, &c., of the Principal Belts.

The salient features lately visible on the planet *Jupiter* are perhaps best described by using the terminology adopted by the *British Astronomical Association*, viz. the North Temperate Band, the North Equatorial Belt, the South Equatorial Belt, the South Temperate Band ; these are the dark bands or belts. The bright zones are called the North Tropical Zone, the Equatorial Zone, and the South Tropical Zone. There are other fainter bands and narrower zones, but of these nothing will be said in this paper.

It was with the object of determining the latitudes of the principal belts that the measures about to be given were made. And it soon became obvious that to do this with great accuracy careful work on really good nights would be required. The present paper is the result of an attempt to do this under the best observing conditions experienced here since January last. And it may at once be said that the definition and steadiness of the image were never of the best quality.

The measures were all made with the 9¾-inch Cooke equatorial refractor and the Simms parallel-wire micrometer ; power, 282.

No attempt was made to *measure* the width of the narrow bands ; the webs were set apart to the estimated width, and then brought near the bands for comparison.

On trial it was found that Mr. Marth's position angle of the polar axis of *Jupiter* plus 90° brought the adjusted web of the micrometer into a position parallel to the equatorial belts. Hence the method adopted was to set the position circle to its zero reading, clamp it, and then adjust the micrometer by a bright and a faint star near the meridian ; then, lastly, move the vernier to the reading for the Jovian equator, and again clamp the position circle.

The value of one revolution of the micrometer screw is 13″·837 ; one division of the divided head =0″·138. One web was placed on the edge or middle of a band, the other just on the north limb of *Jupiter* ; the web was then carried to the other

side of the fixed web, and the measure repeated. Similarly for the south limb.

The Polar Shading.

The dusky regions near the poles were not critically examined, but taken as a whole, and the distances of the north and south edges from the south and north poles of the disc were measured. No doubt the extent of this shaded part of the disc is not quite the same in all longitudes, and this fact may be indicated by the differences in the few results here given.

1896. d	h							
Feb. 12	11	width of N. shading	=	6″·4 ;	of S. shading	=	7″·3
26		„	„	„	7·0 ;	„	„	7·0
Mar. 9		„	„	„	7·7 ;			
Apr. 24		„	„	„	6·6 ;	„	„	6·6

These are reduced to $\Delta = 5\cdot20$.

The North Temperate Band.

As an illustration of the kind of accordance obtained from night to night the following extract from the note books is given :—

1896	h			
April 10	7½	+8″·0	+7″·9	+0″·3
11	8	7·4	7·3	−0·3
12	8½	7·4	7·3	−0·3
13	8	7·9	7·8	+0·2
15	8	7·6	7·5	−0·1
16	8	7·4	7·3	−0·3
20	8	+7·9	+8·0	+0·4

where the distance of the middle of the band from the equator is given in the third column ; the fourth column gives the distances reduced to $\Delta = 5\cdot20$, and the fifth the differences from the mean of all.

1896			Latitude	
Feb. 26 to Apr. 13	...	+7″·25	+24°·3	10 nights
Apr. 15 to Apr. 24	...	7·63	25·7	7 „
Apr. 26 to May 10	...	7·36	24·7	5 „

The mean of all +7″·4, and 24°·9. The width of this band varies in different longitudes ; it has never been a conspicuous band since 1895 October, and it was often difficult to see distinctly enough for a good measure.

Its breadth ranges from about 1½″ to 2½″, the mean of one set of 5 nights' measures being 2″·3, and of another similar set 1″·7.

The North Equatorial Belt.

This is a narrow and comparatively inconspicuous belt in all longitudes, and was seldom well seen. The reduced measures are—

			Width.	
+2″·2	+7°·7	10 nights		
+2·5	+8·6	10 „	1″	5 nights
+2·6	+8·8	10 „	1″	5 „

The means are +2″·4 and +8°·3.

The South Equatorial Belt.

This has been the most salient feature of the planet throughout the present apparition, and could be well seen through terrestrial clouds of considerable density. It is double in all longitudes if we except the small portion just under the Red Spot, where it becomes single.

The middle of the band :

			Means
−4″·0	−13°·1	10 nights	−3″·9 and −13°·1
−3·9	−13·1	10 „	

The north edge :

			Means
−2″·32	−8°·2	9 nights	−2″·2 and −7°·7
−2·27	−7·8	9 „	
−2·1	−7·2	5 „	

The south edge :

			Means
−5″·76	−19°·3	10 nights	−5″·7 and −19°·1
−5·72	−19·0	10 „	

Width of this double band :

3″·5	10 nights	Mean = 3″·5
3·5	10 „	
3·5	10 „	

At its narrowest part, just under the Red Spot, the width is about 1″.

The South Temperate Band.

This was not often seen very distinctly.

−8″·7	−29°·4	10 nights

The North Tropical Zone.

Its width :—

3″·2	5 nights	Mean = 3″·1
3·0	5 „	
3·2	5 „	

The Bright Equatorial Zone.

3″·8	5 nights	Mean = 3″·6
3·6	5 „	
3·3	5 „	

It is possible that some of the discordance in some of the above measures for latitude may arise either from actual differences in latitude of the belt in certain longitudes, or from drift in latitude since the observations began. For a full discussion the longitude of each night's measures would be needed ; the longitude was recorded, but it has not been thought necessary to give it. At any rate the question of drift has already become an interesting and important element in the study of the physical features of *Jupiter*. And the following extracts (especially that from the admirable series of measures by Professor Hough) will be read with interest (see the *Annual Reports of the Dearborn Observatory* ; also *The Observatory*, vol. iv. p. 325, and the *Astronomische Nachrichten*, vol. cxl. p. 169 and p. 273) :—

	1811	1876	1880
South pole to 1st belt ...	13″·60	15″·54	15″·94
„ 2nd „ ...	20·60	19·71	19·34
„ 3rd „ ...	23·67	22·57	24·55
„ 4th „ ...	29·12	28·96	31·86

The measures under 1811 were by Arago, in 1810–13 ; those in 1876 and 1880 by Russell. Latitude of first belt is −36° to −38° ; of second, −18° ; of third, +18° ; of fourth, +36° to +38°.

Dr. L. de Ball has, for 1884–5, the following results :—

N.P.D.	of middle of	great south belt	21″·9
„	„	north „	14·0
S.P.D.	„	south „	15·1
„	„	north „	22·0

Professor Hough's measures are, for the north and south edges of the equatorial zone—*

	1879	1880	1881	1882	1883	1884	1890
	"	"	"	"	"	"	"
North edge	+2·59	2·33	2·16	2·44	2·58	4·95	4·52
South edge	−4·18	4·71	4·75	6·36	5·80	4·69	
Width	6·77	7·04	6·91	8·80	9·30	10·03	9·49

Lastly, the following latitudes, by Dr. E. Lamp, have just appeared in the *Astronomische Nachrichten* (vol. cxl. p. 169); they are for 1896 March :—

North edge of north temperature band		...	+	25°·9
South	,,	,,	...	+ 21·7
North	,,	equatorial band	...	+ 6·0
South	,,	,,	...	+ 2·0
North	,, south	,,	...	− 5·0
South	,,	,,	...	− 16·8
North	,,	temperate band	...	− 28·5
South	,,	,,	...	− 34·1

Observations of Two Dark Spots Seen on One of the Bright Zones of Jupiter.

In the early morning hours of 1895 October 30 an elongated dark spot was noticed near the north edge of the north equatorial belt and in the bright north tropical zone. It was quite detached from the belt; its length was about $2\frac{1}{2}''$, breadth about $1\frac{1}{4}''$, with the longer axis parallel to the dark belt. At the time of its transit across the central meridian its Jovicentric longitude was about 222°. It passed the central meridian of the disc about $3^h\ 47^m$ before Mr. Marth's zero meridian, and is the *grey spot* of the following notes.

Another spot of about the same size and shape, but much darker, was not noticed here until 1896 January 28; it was in longitude 269°, passed the central meridian about $2\frac{1}{2}^h$ before the zero meridian in the same latitude as the grey spot, and is the *dark spot* of the following notes.

A few measures of the length of the *dark spot* were made, but, as the earlier ones differ so much from those made in April of this year, I suspect the accuracy of the former; however, here they are :—1895 November 13, $2''\cdot4$; 1896 January 30, $2''\cdot5$; February 23, $1''\pm$; March 9, $1''\cdot2$ (width, $\frac{1}{2}''+$); April 23, $1''\cdot5$; April 20, $1''\cdot7$; April 28, $1''\cdot4$ (width, $1''$).

* By *Equatorial Zone* Professor Hough means the north equatorial belt, the south equatorial belt, and the bright zone (equatorial) between them. (See *Ast. Nach.* vol. cxl. p. 273.)

The following tables give a complete list of the transits of the spots :—

The Grey Spot.

G.M.T. of Transit.			λ		G.M.T. of Transit.			λ	
1895	d	h m	°		1896.	d	h m	°	
Oct.	29	17 5	222·0	Good.	Feb.	9	6 14·5	197·0	Poor.
Nov.	11	12 47	220·0	Good.		12	13 37·5	196·3	Fair.
	13	14 23	219·3	Fair.		22	11 49·5	196·0	Poor.
	17	7 43	216·5	Good.		23	7 43	195·5	Fair.
	18	13 31	218·0	Poor.		25	9 21	195·2	Poor.
	30	13 15	218·0	Bad.	Mar.	15	10 3	195·9	Poor.
Dec.	19	13 49·5	212·0	Good.		18	7 33	196·0	Poor.
1896.					Apr.	18	7 55·5	184·5	Fair.
Jan.	28	6 35	204·9	Poor.		20	9 27	180·1	Fair.
Feb.	3	11 29	204·8	Bad.		25	8 39	181·8	Good.
	6	8 50·5	200·3	Poor.		30	7 50	182·5	Good.

The first column gives the G.M.T. of the spot's transit over the apparent central meridian ; the second gives the Jovicentric longitude of the spot at central transit ; the last gives an estimate of the quality of the observation at the time.

The Dark Spot.

G.M.T. of Transit.			λ		G.M.T. of Transit.			λ	
1896.	d	h m	°		1896.	d	h m	°	
Jan.	28	8 21	268·9	Poor.	Mar.	18	9 20	260·6	Fair.
	30	9 58	268·3	Fair.		23	8 22	258·5	Bad.
Feb.	6	10 41	367·0	Poor.		25	9 57	254·3	Poor.
	9	8 6	264·5	Poor.		28	7 30	256·1	Poor.
	11	9 40	262·0	Fair.		30	9 9	256·3	Fair.
	14	7 16	266·0	Poor.	Apr.	9	7 23	254·0	Fair.
	23	9 35	263·1	Fair.		11	8 58	252·0	Poor.
	24	5 30	265·4	Poor.		16	8 6	250·7	Fair.
	26	7 6	263·4	Fair.		18	9 45·5	251·9	Fair.
Mar.	1	10 15	259·4	Fair.		20	11 29	253·8	Fair.
	4	7 48	261·5	Fair.		23	8 54	250·6	Good.
	6	9 25	260·6	Poor.		28	8 3	250·1	Fair.
	8	11 5	261·0	Poor.		30	9 43	250·7	Fair.
	9	6 55	260·7	Fair.	May	5	8 50·5	249·6	Good.
	16	7 43	261·6	Poor.		10	8 0	249·2	Good

Taking observations not less than about ten days apart the following series of ten is obtained :—

The Dark Spot.

Observed G.M.T. of Transit.				λ	L	Δ	R
1896.	d	h	m	°	°		
Jan.	28	8	21	268·9	123·6	4·30	0
Feb.	14	7	16	266·0	121·9	4·37	41
	26	7	6	263·4	120·3	4·47	70
Mar.	4	7	48	261·5	119·8	4·55	87
	16	7	43	261·6	119·2	4·69	116
	25	9	57	254·3	119·1	4·82	138
Apr.	9	7	23	254·0	119·5	5·07	174
	23	8	54	250·6	120·4	5·28	208
	30	9	43	250·7	121·1	5·39	225
May	10	8	0	249·2	119·8	5·54	249

where λ is the Jovicentric longitude of the spot, L the geocentric longitude of *Jupiter*, Δ the distance of the Earth from *Jupiter*, and R the number of rotations.

A few trials showed that a period of $9^h\ 55^m\ 30^s$ very nearly represented the observations. This was adopted as the assumed period. The observations were then corrected for longitude and aberration, all being reduced to geocentric longitude 125° and to Δ = 5·20 ; and thus the corrected times were obtained.

Putting a for the error of the first aberration, ρ for the correction of the assumed period, T for the corrected time of an observation, and T_o the corrected interval between any observation and the first, the equations of condition take the form

$$a + N\,(595^m{\cdot}5 + \rho) = T - T_o.$$

N = the number of rotations.

From the ten equations of condition the two normal equations were derived and solved, and the following values resulted :

$$a = -0^m{\cdot}67 \qquad \rho = +0^m{\cdot}05.$$

Hence the period is $9^h\ 55^m\ 33^s$.

With the help of the Greenwich Mean Times when the zero-meridian passed the middle of the illuminated disc (given in Mr. Marth's ephemerides) in the assumed System II., the period of rotation is very readily found when the observed times of transit of the spot are known, and the value thus obtained is identical with that just given.

The Grey Spot.

1895. d	h	m	λ	L	Δ	R
			°	°		
Oct. 29	17	5	222·0	128·0	5·2	0
Nov. 11	12	47	220·0	128·8	5·0	31
Dec. 19	13	49·5	212·0	128·2	4·5	123
1896.						
Jan. 28	6	35	205·0	123·6	4·3	219
Feb. 25	9	21	195·0	120·4	4·5	287
Mar. 15	10	3	196·0	119·3	4·7	333
Apr. 18	7	55·5	184·0	119·7	5·2	415
30	7	50	182·0	121·1	5·4	444

Correcting as before, reducing to $L = 130°$ and $\Delta = 5{\cdot}20$, forming the equations of condition, and solving the two normal equations, the period is found to be $9^h\ 55^m\ 32^s$.

The Latitude of the Spots.

The distance from the centre of the dark and grey spots to the north and south poles was measured on every fine night between 1895 October 29 and 1896 May 10, the micrometer being set to the computed position angle of *Jupiter's* equator. The first measures, made when the planet was low and the motion very great, viz. in 1895 October and November, gave a mean distance of $4\frac{1}{2}''$ from the Equator north.

This distance is probably in excess of the true value. The following is a complete list of the results derived from the measures from January 30 to May 10, 1896. Under *a* are given the distance from the Equator ; Δ is the distance of the planet from the Earth ; B is the B of Mr. Marth's ephemerides ; and *b* gives the values under *a* reduced to $\Delta = 5{\cdot}20$.

a	Δ	B	*b*	*a*	Δ	B	*b*
"		°	"	"		°	"
+4·4	4·31	+0·48	+3·6	+4·5	4·79	0·59	4·1
4·4	4·33	·50	3·6	4·6	4·90	·59	4·3
5·6	4·36	·52	4·7	4·2	5·05	·58	4·1
5·5	4·37	·52	4·6	4·2	5·09	·58	4·1
4·4	4·44	·54	3·7	4·3	5·20	·57	4·3
4·6	4·47	·55	3·9	3·8	5·24	·57	3·8
4·5	4·51	·56	3·9	4·4	5·28	·56	4·5
5·2	4·61	·57	4·6	4·3	5·33	·56	4·4
4·8	4·68	·58	4·3	4·5	5·36	·55	4·6
4·4	4·72	·58	4·0	4·4	5·54	·52	4·7

Taken in groups of five the means are $4''\cdot1$, $4''\cdot1$, $4''\cdot2$, $4''\cdot2$, $4''\cdot4$; and $4''\cdot2$ the mean of all. With the help of Mr. Marth's values of B and the formula

$$\sin(\beta' - B') = \frac{y}{b},$$

the latitude of the two spots is found to be $+14°\cdot2$.

The measures seem to indicate a slight increase in the latitude in the period embraced by the observations. Dr. Lamp (*Ast. Nach.* vol. 140, p. 170) gives the latitude $+12°\cdot3$, 1896 March 23, from micrometric measures of the distance d, from the centre of the planet's disc, "unter Vernachlässigung der Neigung der Bahnebene und der Rotationsaxe des Planeten nach der Formel

$$\tan\phi = \frac{b}{a} \cdot \frac{d}{\sqrt{(b+d)(b-d)}}$$

berechnet."

As it is almost certain that a dark spot seen here in 1894 November is identical with the *Grey Spot*, the following observations will probably have some interest for observers of these phenomena.

1894 November 5.—A dark oblong spot under the north equatorial dark band; central transit about $10^h\ 58^m$.

1894.	G.M.T. of Transit. d	h	m	Before the Zero Merid. h	m	Jovicentric Longitude. °
Nov.	5	10	58	3	19	239·3
	15	9	10·5	3	21	238·2
	17	10	47·5	3	22	237·6
1895.						
Jan.	2	8	31	3	28·7	233·8
	21	9	5	3	33·6	231·0
	26	8	16·5	3	30	233·3
1895.						
Feb.	7	8	9·5	3	31·8	232·3
	9	9	46	3	33·8	231·1
	12	7	15	3	34·8	230·6
Mar.	1	6	15	3	39·9	227·6
Apr.	15	8	38	3	38·8	228·5

Measures of the Position of Jupiter's Satellites and their shadows when in transit across the Disc.

In the *Monthly Notices* of the Society, Vol. 55, p. 536, Mr. Marth points out "that the most promising means for determining the longitudes of the nodes of the orbits (of *Jupiter's* satellites) with accuracy would be found in micrometrical measurements of the rectangular coordinates of the shadows of the satellites near their mid-transits, if these measurements are made about the times when the planes of the orbits pass through the Sun. Though the opportunities of 1884, and at the next nodal passages in 1890, pointed out in Vol. 50, p. 347, appear to have been neglected, observers ought to be reminded of their opportunities offered during the present apparition of *Jupiter*." See also Vol. 44, p. 241. It was in response to this appeal that attempts have been made here on suitable occasions to measure the rectangular coordinates of Satellite I. and also of the shadows of I. and III.

It was very soon found that the measurements of the x co-ordinate could have no value owing to the swaying to and fro of the image of *Jupiter* due mostly no doubt to imperfect driving of the clock.

The measures were made with the Simms Parallel-wire micrometer and the $9\frac{1}{3}$-inch Cooke Equatorial Refractor, power 282. The times are in Greenwich Mean Time. 1896 February 23. Clear, calm; fair definition. Ingress of shadow of Satellite III. about $6^h\ 11^m$; central about $7^h\ 57^m$; egress at $9^h\ 44^m$.

The micrometer was carefully adjusted on a bright and then on a faint star, then set to the given position angle and clamped. The measurement went on continuously from $6^h\ 30^m$ till $9^h\ 20^m$. In column a is given the distance from the centre of the shadow to the S. pole of the apparent disc, and in b the distance to the N. pole; c gives the sum of these distances; d the number of double measures; e the difference from the mean.

a	b	c	d	e	a	b	c	d	e
18·4	24·2	42·6	2	−0·5	18·9	24·9	43·8	2	+0·7
17·7	25·2	42·9	2	−0·2	18·3	25·3	43·6	2	+0·5
18·0	24·5	42·5	2	−0·6	18·3	25·3	43·6	2	+0·5
18·0	24·1	42·1	2	−1·0	18·3	25·2	43·5	2	+0·4
18·3	24·2	42·5	2	−0·6	18·4	24·9	43·3	2	+0·2
18·3	24·9	43·2	2	+0·1	18·0	25·3	43·3	2	+0·2
18·0	25·0	43·0	2	−0·1	17·7	24·6	42·3	4	−0·8
18·4	25·3	43·7	2	+0·6	18·0	24·9	42·9	2	−0·2
17·7	24·6	42·3	2	−0·8	18·0	24·8	42·8	6	−0·3
18·0	25·3	43·3	2	+0·2	18·4	25·0	43·4	2	+0·3
18·3	25·9	44·2	2	+1·1	18·4	25·0	43·4	2	+0·3
18·4	25·6	44·0	2	+0·9	17·8	24·7	42·5	6	−0·6

Mean of numbers in column $c = 43''{\cdot}1$.

All measures are given to the nearest tenth of a second.

1896 April 6: shadow of III. in transit; shadow central about $7^h\ 35^m$. Position angle 103°·8.

The measures began at $7^h\ 10^m$ and ended at 8^h.

a	b	c	d	e	a	b	c	d	e
15·9	20·9	36·8	2	−0·9	16·5	21·3	37·8	2	+0·1
16·4	20·7	37·1	2	−0·6	16·4	21·0	37·4	2	−0·3
16·3	20·9	37·2	2	−0·5	16·5	21·4	37·9	2	+0·2
16·7	21·0	37·7	2	0·0	16·7	21·1	37·8	2	+0·1
16·9	21·3	38·2	2	+0·5	16·6	21·4	38·0	2	+0·3
16·7	20·7	37·4	2	−0·3	16·5	21·4	37·9	2	+0·2
16·4	20·9	37·3	2	−0·4	16·8	20·8	37·6	2	−0·1
16·8	21·5	38·3	2	+0·6	16·5	21·5	38·0	2	+0·3
16·7	21·0	37·7	2	0·0	16·9	21·0	37·9	2	+0·2
16·6	20·7	37·3	2	−0·4	17·0	21·0	38·0	2	+0·3

Mean = 37″·7.

The webs of the micrometer were brought up to the limbs of the planet and then placed just on them. One revolution of the screw=13″·837 ; one division of the divided head=0″·138 ; thickness of the web about 0″·2.

1896 March 18 : shadow of Satellite I. in transit ; ingress $7^h\ 55^m$; egress $10^h\ 9^m\ 30^s$; Position angle 102°·5.

When near mid-transit six double measures were made from shadow to N. and S. limbs of *Jupiter* :—

Distance from N.	20″·6	21″·2	21″·2	21″·0	21″·0	21″·2
Distance from S.	19·4	19·8	19·1	19·1	18·9	19·2
The sums are	40·0	41·0	40·3	40·1	39·9	40·4

Mean = 40″·3. Differences −0″·3, +0·7, 0·0, −0·2 −0·4, +0·1.

The definition being good and the image fairly steady, the following measures of the x coordinate were made.

a from W. limb ; b from E. limb ; c the sum of a and b ; d the number of double measures ; e difference from the mean.

a	b	c	d	e	a	b	c	d	e
27″·5	15″·2	42″·7	2	−0″·2	21″·3	22″·1	43″·4	2	+0″·5
27·0	15·5	42·5	2	−0·4	21·7	22·5	44·2	2	+1·3
27·5	15·5	43·0	2	+0·1	20·3	23·8	44·1	2	+1·2
24·9	17·3	42·2	2	−0·7	17·8	25·2	43·0	6	+0·1
24·9	18·1	43·0	2	+0·1	13·4	30·0	43·4	2	+0·5
24·2	19·2	43·4	2	+0·5	15·2	27·7	42·9	2	0·0
22·1	19·5	41·6	2	−1·6	15·2	28·1	43·3	2	+0·4
20·1	21·4	41·5	2	−1·4					

Mean = 42″·9.

The above measures were made continuously from $8^h\ 25^m$ till $9^h\ 20^m$.

The shadow moved along the bright central zone at a distance of 1″·7 from the north edge of the ruddy band (double) just south of *Jupiter's* equator.

1896 March 18 : Satellite I. in transit ; ingress, $6^h\ 52^m\ 25^s$; egress, $9^h\ 8\frac{1}{2}^m$.

This was a dark transit, the satellite appearing as a dusky round spot. When it was central three measures of its distance from the north and three from the south limb were made :—

From north = 21″·4 From south = 18″·1 Sum. = 39″·5.

Three sets of measures from the east and west limbs were made between $7^h\ 47^m$ and $7^h\ 54^m$:—

From East Limb.	From West Limb.	Sum.
18″·7	23″·9	42″·6
18·7	24·5	43·2
17·6	23·5	41·1

Mean = 42″·3; differences +0·3, +1·1, −1·2.

1896 April 26 : Shadow of I. in transit ; ingress, $6^h\ 27^m$; egress, $8^h\ 47^m$. Position angle 104°·1.

When nearly central (but on east side of central meridian) the following measures were made :—

Distance from North Pole.	Distance from South Pole.	Sum.	Differences.
18″·0	16″·9	34″·9	−0″·5
18·0	17·0	35·0	−0·4
18·4	17·0	35·4	0·0
18·2	17·3	35·5	+0·1
18·4	16·9	35·3	−0·1
18·8	16·9	35·7	+0·3
18·8	17·0	35·8	+0·4
18·8	17·1	35·9	+0·5
18·4	16·6	35·0	−0·4
18·9	17·0	35·9	+0·5

Mean = 35″·4.

The shadow was central about $7\frac{1}{2}^h$. It moved along the bright central zone at a distance of 1″·4 from the north edge of the ruddy double band just south of *Jupiter's* equator.

Observations of Phenomena of Jupiter's Satellites with the $9\frac{1}{3}$-inch Cooke Equatorial Refractor at Mr. Crossley's Observatory, Bermerside, Halifax, in 1895–6. By Joseph Gledhill.

Day of Obs.	Satellite.	Phenomenon.	Phase.	G.M.T. of Observation.	G.M.T. of *N. Almanac.*
1895.				h m s	h m s
Oct. 29	I.	Ec. D.	Fading	15 6	15 7 19
			Bisection ?	15 7	
			Just gone	15 7 40	
	II.	Ec. D.	Fading	16 35	16 35 58
			Bisection ?	16 36	
			Just gone	16 36 50	
Nov. 30	I.	Ec. D.	Fading	11 34	11 36 16
			Bisection ?	11 35	
			Just gone	11 36 41	

Day of Obs.	Satellite.	Phenomenon.	Phase.	G.M.T. of Observation. h m s	G.M.T. of *N. Almanac.* h m s
1895.					
Dec. 1	IV.	Ec. R.	First seen	11 54 3	11 58 34
			Bisection	11 59	
9	I.	Oc. R.	Bisection	11 13	11 15
			Ext. contact	11 15	
1896.					
Jan. 24	I.	Oc. R.	Ext. contact	10 35	10 34
Feb. 6	II.	Ec. R.	First seen	7 48 16	7 48 3
			Bisection	7 52	
			Full?	7 54	
	IV.	Ec. R.	First seen	12 13 10	12 17 19
			Bisection?	12 18	
			Full?	12 23	
9	I.	Ec. R.	First seen	8 49 39	8 49 59
			Bisection	8 51	
			Full	8 54	
13	II.	Ec. R.	First seen	10 24	10 23 35
			Bisection?	10 25	
23	III.	Sh. I.	Bisection	6 11	
			Int. contact	6 13	6 14
	IV.	Ec. R.	First seen	6 18 52	6 22 27
			Bisection	6 24	
			Full	6 29	
	III.	Tr. E.	Bisection	6 59	7 2
			Ext. contact	7 1	
	I.	Oc. D.	Ext. contact	9 33	9 39
			Bisection	9 34	
			Just gone	9 35 30	
	III.	Sh. E.	Int. contact	9 40 30	9 54
			Bisection	9 44	
			Ext. contact	9 45 30	
24	I.	Tr. I.	Ext. contact	6 59 20	6 58
			Bisection	7 1	
			Int. contact	7 2	
Mar. 1	III.	Tr. I.	Ext. contact	6 49	6 49
			Bisection	6 51	
			Int. contact	6 54	
	III.	Sh. I.	Bisection	10 12 30	10 13
			Int. contact	10 14	
2	I.	Tr. I.	Ext. contact	8 47	8 45

Day of Obs. 1896.	Satellite.	Phenomenon.	Phase.	G.M.T. of Observation. h m s	G.M.T. of *N. Almanac.* h m s
			Bisection	8 48 30	
			Int. contact	8 50	
	I.	Sh. I.	Int. contact	9 40	9 37
Mar. 8	III.	Tr. I.	Int. contact	10 25	10 19
9	II.	Ec. R.	First seen	7 26 58	7 27 32
			Bisection ?	7 29	
			Full ?	7 30	
	I.	Tr. I.	Ext. contact	10 34 50	10 33
			Bisection	10 36 20	
			Int. contact	10 38	
	I.	Sh. I.	Bisection	11 34	11 31
			Int. contact	11 35 30	
12	III.	Ec. R.	First seen	7 41 31	7 41 57
			Bisection	7 46	
			Full	7 49	
16	II.	Ec. R.	First seen	10 2 20	10 2 46
			Bisection	10 5	
			Full ?	10 8	
17	I.	Oc. D.	Ext. contact	9 29 51	9 31
			Bisection	30 46	
			Just gone	32 1	
18	I.	Tr. I.	Ext. contact	6 50 40	6 49
			Bisection	6 52 25	
			Int. contact	6 54	
	I.	Tr. E.	Int. contact	9 7	9 9
			Bisection	9 8 30	
			Ext. contact	9 11	
	I.	Sh. E.	Int. contact	10 8	10 15
			Bisection	10 9 30	
			Ext. contact	10 12 45	
19	III.	Oc. R.	Bisection	7 12	7 15
	III.	Ec. D.	Fading	8 4 30	8 9 38
			Bisection	8 6 30	
			Just gone	8 11 33	
	IV.	Sh. E.	Int. contact	8 28	8 48
			Bisection	8 30 30	
			Quite off ?	8 35	
23	II.	Oc. D.	Ext. contact	7 28 20	7 28

Day of Obs. 1896.	Satellite.	Phenomenon.	Phase.	G.M.T. of Observation. h m s	G.M.T. of *N. Almanac.* h m s
			Bisection	7 30 30	
			Just gone	7 31 50	
Mar. 30	II.	Oc. D.	Ext. contact	9 56 10	9 57
			Bisection	9 58 2	
			Just gone	5 59 10	
Apr. 2	III.	Oc. D.	Ext. contact	11 2 30	11 6
			Bisection	11 6 20	
			Just gone	11 11 20	
	I.	Ec. R.	First seen	11 13 0	11 13 14
			Bisection	11 15 30	
			Full	11 18 30	
3	I.	Tr. E.	Bisection	7 18	7 19
			Ext. contact	7 20	
	I.	Sh. E.	Int. contact	8 28 40	8 34
			Bisection	8 30 20	
8	II.	Tr. E.	Int. contact	9 35	9 43
			Bisection	9 36 30	
			Ext. contact	9 38 30	
	II.	Sh. I.	Int. contact	9 19	9 17
9	I.	Oc. D.	Ext. contact	9 32 50	9 35
			Bisection	9 34 40	
			Last seen	9 35 50	
10	I.	Tr. I.	Ext. contact	6 55 20	6 52
			Bisection	6 57	
			Int. contact	6 58 10	
	II.	Ec. R.	First seen	7 5 50	7 5 35
			Bisection	7 8	
			Full	7 10	
	I.	Sh. I.	Int. contact	8 10	8 8
	I.	Tr. E.	Int. contact	9 8	9 12
			Bisection	9 10	
			Ext. contact	9 11 30	
11	I.	Ec. R.	First seen	7 37 21	7 37 28
			Bisection	7 39	
			Full	7 41	
13	III.	Tr. E.	Bisection	8 35 30	8 39
			Ext. contact	8 39 30	
	IV.	Ec. D.	Fading	7 52	7 56 58
			Bisection	7 55	
			Last seen	7 59 40	

Day of Obs.	Satellite.	Phenomenon.	Phase.	G.M.T. of Observation.	G.M.T. of *N. Almanac.*
1896.				h m s	h m s
Apr. 17	II.	Ec. R.	First seen	9 40 25	9 40 31
			Bisection	9 42 30	
			Full	9 45	
18	I.	Ec. R.	First seen	9 32 50	9 32 56
			Bisection	9 34 30	
			Full	9 37	
20	III.	Tr. I.	Ext. contact	9 0 40	8 59
			Bisection	9 3 30	
			Int. contact	9 5 22	
21	IV.	Tr. E.	Int. contact	8 35	8 35
			Bisection	8 37	
			Ext. contact	8 41	
24	III.	Ec. R.	First seen	7 43 34	7 42 48
			Bisection	7 47	
			Full	7 51	
25	I.	Oc. D.	Ext. contact	7 51 30	7 53
			Bisection	7 54	
			Just gone	7 55 5	
26	I.	Tr. E.	Int. contact	7 27	7 30
			Bisection	7 29 37	
			Ext. contact	7 31	
May 3	I.	Sh. I.	Int. contact	8 24	8 21
	II.	Sh. E.	Quite off	9 20	9 26
	I.	Tr. E.	Int. contact	9 24	9 26
			Bisection	9 25	
			Ext. contact	9 26 30	
10	II.	Tr. I.	Ext. contact	6 41	6 43
			Bisection	6 43	
			Int. contact	6 45	
	I.	Tr. I.	Ext. contact	9 6	9 3
			Bisection	9 7 30	
			Int. contact	9 9	
	II.	Tr. E.	Int. contact	9 29	9 38
			Bisection	9 32	
			Ext. contact	9 34	
11	I.	Ec. R.	First seen	9 47 50	9 48 14
			Bisection	9 49 30	
			Full?	9 53	

Notes.

Powers used, 240 and 282.

1895 Oct. 29, planet low; bad definition. Nov. 30, windy; planet low; much motion. Dec. 1, clouds; violent motion. Dec. 9, stormy; no definition. 1896 Jan. 24, windy and wet. Feb. 6, bad definition. Feb. 9, planet low; much boiling. Feb. 13, overcast sky. Feb. 23, much motion. Feb. 24, good definition. Mar. 1, stormy. Mar. 2, very stormy. Mar. 8, stormy. Mar. 9, good definition. Mar. 12, misty. Mar. 16, stormy. Mar. 17, windy; clouds. Mar. 18, good definition. Mar. 19, good. Mar. 23, much cloud. Mar. 30, much cloud. Apr. 2, clouds. Apr. 3, good. Apr. 8, good. Apr. 9, windy; cloud. Apr. 10, windy; cloud; much motion. Apr. 11, windy. Apr. 13, good. Apr. 17, fair; cloud. Apr. 18, fair. Apr. 20, good; mist. Apr. 21, good. Apr. 24, fair; in twilight. Apr. 25, bad. Apr. 26, bad. May 3, good. May 10, fair; first obs. made 1^h before sunset. May 11, fair.

The powers used were 150 when definition was bad, 240 on most occasions, and 330 and 470 when the image was very steady and the sky clear.

Opp 24 Jan 96 . 19 Ap □

On certain Phenomena presented by Jupiter's Satellites and their Shadows during Transit, with a Note on the Red Spot; and on some Methods of observing the Transits of Bright and Dark Spots across the Central Meridian. By J. Gledhill.

Careful observations of the changes which the satellites and their shadows undergo while in transit across the disc of Jupiter are slowly accumulating. Among recent contributors the names of Pritchett, Trouvelot, Tebbutt, Barnard, Denning, Spitta, and Williams may be mentioned. The elaborate researches of Spitta, together with the suggestions and theories of Burton, Proctor, Schaeberle, Holden, Hough, Williams, and others, constitute a real advance in the direction of a scientific explanation of these interesting phenomena. It was with the view of widening the basis for such investigations that the following observations were made. The instrument used was the $9\frac{1}{3}$-in. Cooke equatorial refractor, powers 240 and 270, Huyghenian, and 282 on the Simms' micrometer. The observations were begun in the early morning hours of 1895 October, and concluded in the early evenings of May of the present year.

Satellite I.

Satellite I. in transit 1896 March 2 : ingress at $8^h\ 48\frac{1}{2}^m$; invisible about $9^h\ 10^m$. It passed along the bright central zone of *Jupiter*.

Satellite I. in transit, 1896 March 9 : ingress at $10^h\ 36^m\ 20^s$. It traversed the bright central zone just below (to north of) the ruddy double belt, and was a bright and conspicuous object when just within the disc. At $10^h\ 42^m$ it was less bright, and gradually grew fainter till $10^h\ 55^m$, when it was just visible; it was invisible at 11^h. At $11^h\ 10^m$ it reappeared as a very faint

dusky round spot, was darker at $11^h\ 15^m$, and easily seen as a dusky spot at $11^h\ 30^m$; central about $11^h\ 38^m$, faint at $11^h\ 50^m$, and seen with difficulty at 12^h.

Satellite I. in transit 1896 March 18 : ingress at $6^h\ 52^m\ 25^s$, just visible as a bright disc at $7^h\ 10^m$, invisible at $7^h\ 15^m$, and till $7^h\ 30^m$; at $7^h\ 33^m$ it was seen as a dusky spot; it grew darker, and so continued till $8^h\ 30^m$; at $8^h\ 40^m$ it was less dark; very faint at $8^h\ 50^m$, and invisible at 9^h. It was not so bright when just about to leave the disc as it was at ingress when just within the eastern limb.

Satellite I. in transit, 1896 March 25 : ingress about $8^h\ 40^m$; brighter than the limb of *Jupiter* when just within the disc at $8^h\ 50^m$; very faint at 9^h; invisible at $9^h\ 10^m$; a dusky spot at $9^h\ 30^m$ and 10^h; darker at $10^h\ 15^m$ and onwards; clouds prevented further observation. The satellite traversed the bright central zone about $1\frac{1}{2}''$ to the north of the ruddy double band which lies just to the south of *Jupiter's* equator.

Satellite I. in transit 1896 April 10 : ingress at $6^h\ 57^m$; it moved along the bright central zone and near the ruddy belt; was much brighter than the adjacent surface of *Jupiter* at ingress; growing faint at $7^h\ 10^m$; very faint at $7^h\ 15^m$; invisible at $7^h\ 30^m$; reappeared as a grey spot at about $7^h\ 40^m$, and so continued till $8^h\ 50^m$; invisible at 9^h; brightening at $9^h\ 5^m$.

Satellite I. in transit 1896 April 17 : ingress about $8^h\ 46^m$; brighter than the limb of *Jupiter*; grew gradually fainter, and was invisible at $9^h\ 10^m$; reappeared at $9^h\ 30^m$ as a grey spot.

The Shadow of Satellite I.

On 1896 March 18 the shadow was slightly elongated in a direction parallel to the belts, and seemed smaller at ingress than just before it left the disc. ? egress

In transit 1896 April 3 : ingress at $8^h\ 30^m\ 20^s$; clouds prevented observation until the shadow had passed the central meridian of *Jupiter's* disc. Between the c. meridian and the western limb the shadow for some time appeared perfectly circular; it then became elongated in a north and south direction, then showed a penumbral fringe on its east and west sides, and then became elongated in a direction not quite parallel to the belts of *Jupiter*.

Satellite II.

In transit April 8 : ingress about $6^h\ 48^m$; not seen from 7^h to 9^h; still invisible at $9^h\ 20^m$; quite bright and near the western limb of *Jupiter* at $9^h\ 30^m$.

Satellite III.

In transit 1896 March 1 : ingress at $6^h\ 51^m$; at 7^h invisible; seen as a dusky spot at $7^h\ 20^m$; it so remained till $9^h\ 40^m$; at

9^h 55^m it was not so dark ; at 10^h 5^m not easily seen ; at 10^h 10^m invisible.

In transit 1896 March 8 : brighter than the limb of *Jupiter* at ingress ; soon became a dark spot. It was on the ruddy belt just south of the equator. The weather was bad, and further observations impossible.

In transit 1896 April 13 : the satellite became quite dark, nearly as black as a shadow, soon after ingress, and continued so all the way across the disc of *Jupiter* till 8^h 18^m, when it became less dark ; grew gradually fainter till 8^h 25^m ; was invisible at 8^h 30^m and 8^h 34^m, and quite bright at 8^h 35^m, when near egress.

In transit 1896 April 20 : it moved along the ruddy belt just south of *Jupiter's* equator ; was brighter than the adjacent surface of the planet at 9^h 6^m ; growing fainter at 9^h 10^m ; still easily seen at 9^h 15^m ; just visible at 9^h 23^m ; appeared as a grey spot at 9^h 25^m ; darker at 9^h 30^m ; at 10^h nearly as dark as a shadow, and so continued till after 12^h.

The Shadow of Satellite III.

In transit 1896 February 23 : ingress at 6^h 13^m ; very large, black, distinctly elongated in a direction not quite parallel to the belts of *Jupiter*, and so remained for half an hour, then became circular. It was a most striking object for some time, indeed, until it had passed the central meridian. As it passed away from the meridian westward it became altogether a less conspicuous object, and so remained quite up to egress. The definition was so good that all the stages of the egress were easily observed—round when in contact, then imperfect, then half had disappeared, then a black crescent-like form, finally, a thick black curved line, and then total disappearance at 9^h 45^m 30^s.

In transit 1896 March 1 : ingress at 10^h 12^m 30^s, and was black and circular in shape, and of its usual appearance throughout the transit.

An exceptionally fine view of the disappearance of Satellite III. in *Jupiter's* shadow was obtained on 1896 March 19. From 8^h to 9^h the definition was very fine indeed, and the various stages of disappearance were so beautifully seen as to call to mind Professor Pickering's account of these phenomena as seen at Arequipa—"*Phase.* We now come to an observation of which only the most favourably located telescopes are capable, that of watching the change of shape as the satellite enters the shadow of its primary." "The phases of *Jupiter's* satellites are readily observed as they enter into the shadow of the planet, a phenomenon which it is thought but few astronomers have ever seen even with much larger telescopes than the 13-inch" (*Astronomy and Astrophysics*, vol. xi. p. 355). On the present occasion every phase was distinctly and easily seen—full orb just before the satellite touched the shadow, slight deformation, bisection, a

delicate crescent-like form, a fine curved line of light, then a minute speck of light just before complete extinction. It is perhaps needless to add that no trace of the penumbra of *Jupiter's* shadow was seen on the satellite, a very high power and a still finer sky being necessary for such an observation.

Satellite IV.

In transit 1896 April 21 : ingress about $3^h\ 56^m$; when first seen, before sunset, it was a fine object well advanced on the disc of *Jupiter* ; it was circular and as black as a shadow, and so remained till it approached the western limb, when it became smaller but not less dark. When one half of the satellite still remained on the disc, the other half could not be seen against the dark sky ; and even when the whole disc of the satellite was off the planet it was probably no brighter than one of the grey belts. At about 9^h it became brighter. During transit it moved along the south edge of the ruddy belt.

The Shadow of Satellite IV.

In transit 1896 March 19 : watched it from 6^h till egress ; circular till $7^h\ 15^m$; then distinctly elongated in a direction perpendicular to the belts of *Jupiter*, and thus remained till $7^h\ 45^m$. It moved along the ruddy band.

Note on the Red Spot, &c.

Throughout the whole of the present apparition of *Jupiter* the Red Spot was carefully looked for when in transit, but was never, even on nights of good definition, distinctly and steadily seen. Its outline was occasionally seen for a moment. No colour was ever seen within the outline. Some adjacent features, however, could not be overlooked, viz. the *Preceding Shoulder*, the *Following Shoulder*, and the great trough between them under the Red Spot. A few measures were made of the distance from shoulder to shoulder, but owing to the faintness of the preceding shoulder they were but rough : 1896 February 26, $11''{\cdot}8$; $11''{\cdot}1$ on March 12 ; and $11''{\cdot}9$ on April 29, all reduced to $\Delta = 5{\cdot}20$. The depth of the trough, from the south edge of the south equatorial belt (here quite narrow) to the north edge of the south temperate band, and through the Red Spot, was $4\frac{1}{2}''$ on 1896 March 12.

Although the preceding and following shoulders and the trough between them do not offer any very definite points for the eye to rest on, attempts were made to obtain the times of their transits across the central meridian with the following results :—

The Preceding Shoulder.

1896.	h m			h m	
Mar. 2	8 44	λ = 354°8	Apr. 2	9 16	λ = 351°0
9	9 30	354·4	9	9 59	349
12	7 0	353·5	24	7 33	351·6
16	10 10½	350	May 6	7 35	353·8
19	7 45	353·3			

The Middle of the Hollow or Trough.

Feb. 26	9 55	λ = 6·2	Apr. 9	10 30	λ = 7·0
Mar. 9	9 53	8·4	12	8 0	6·5
12	7 23	7·4	May 6	7 55	5·9
16	10 37½	6·6	9	5 30	8·7
Apr. 2	9 42	6·7			

The Following Shoulder.

Mar. 2	9 32½	λ = 24·1	Apr. 29	7 38	λ = 25·3
9	10 23	26·4	May 6	8 27	25·3
12	7 52	24·9	9	5 58	25·6
16	11 0	26·6	11	7 38	26·2
Apr. 2	10 12	24·8	13	9 17	26·2
9	11 0	25·0			

Note on some Methods of Observing the Transits of Bright and Dark Spots across the Central Meridian.

It has occurred to me that the following notes might be of some use to Fellows of the Society who live at a distance from London, and to whom many of the Continental and American astronomical publications are not readily accessible.

1. *Simple eye-estimations.*—This is no doubt the method in most general use by amateur astronomers, and it may be encouraging to many to know that it was the method exclusively practised by Mr. Barnard for many years. When skilfully used the results obtained are comparable with ordinary micrometrical measures. "Careful eye-estimates," writes Mr. Barnard, "I think, should have the same value as micrometrical measures for determining the times of transit of the spots on *Jupiter*" (*Monthly Notices*, vol lii., p. 11). And again: "Among the observations of the Red Spot I have forty-four complete and carefully estimated transits—that is, observations of the preceding end, middle, and following end of the spot. Twenty-one of these are from a single but careful estimate of each phase. These give a probable error of a transit of the centre from the mean of the three observations $= \pm 1^{m}\cdot0$. In twenty-three of these transits three estimations were made of each phase; from these I get for the transit of the middle from the mean of the time observations the error

of the transit $= \pm 0^m \cdot 7$" (*Publications of the Astronomical Society of the Pacific*, vol. i., p. 91). He further found that his observations of the Red Spot "indicate a probable error of $\pm 0^\circ \cdot 44$ or $\pm 0^m \cdot 73$ in the determination of the time of transit by a single estimate."

On the other hand, it is well to remember Mr. Marth's warning after he had reduced a large number of estimated times of transit of the Red Spot by various observers. He writes: "The discrepancies between the observations of different observers and on different days point to the existence of some grave sources of error, and show the necessity for greater care and caution" (*Monthly Notices*, vol. xl., pp. 420–428).

Again: Dr. Schmidt paid considerable attention to this subject, and in his papers in the *Astronomische Nachrichten*, Nos. 2,342 and 2,410, discusses 180 observations of transits of the Red Spot. He finds a mean error of $2^m \cdot 57$ for the time of transit; that personal equation affected the results of different observers to an extent varying between $+3^m \cdot 6$ and $-5^m \cdot 8$; and, lastly, he detected a systematic error in the observations depending on the hour angle, its maximum value being 7^m. (See also *Astronomy and Astro Physics*, vol. xi., 1892.) On the whole, it may be said that there is a probable error of $\pm 2\frac{1}{2}^m$, and a possible one of 7^m or 8^m, or even more.

2. Webs or wires are placed so as to cut off similar segments of the disc on each side of the central meridian.

3. Webs or wires are placed as tangents to the ends of a spot and the times noted (*a*) when the first web bisects the disc; (*b*) when the webs cut off equal sections of the disc; (*c*) when the second web bisects the disc. The mean of (*a*) and (*c*) should not differ more than 1^m from (*b*). This is Professor Pritchett's method (*Astronomische Nachrichten*, vol. xcvi., p. 223).

4. A thick wire (of known thickness) is placed so as to bisect the disc, while another wire is tangent to one limb of the planet. The times are noted (1) when the preceding end of the spot touches the thick wire; (2) when it reappears at the other edge of the wire. Then the mean of the times is the time of transit of that end of the spot. Similarly for the following end. This is Jedrzejewicz's method. (See *Astronomische Nachrichten*, vol. xcix., p. 211.)

5. When Mr. Barnard used a micrometer he "bisected the equatorial belts by a vertical micrometer wire, and noted the time when the object passed behind the wire" (*Monthly Notices*, vol. lii., p. 7).

6. *Micrometer measures from the two limbs of the planet to the spot.*—This is, of course, the best of all, when the atmospheric conditions and the driving of the clock are good. A considerable saving of time is also effected by this method; one has not to wait until the spot is central; its position may be measured nearly as soon as it is distinctly seen; though, of course, the best results are obtained when the spot is not more than 30^m from the central

meridian. Measures may be made on one or both sides of the meridian, and they may be repeated three or more times, so as to reduce the accidental errors. This method has been most extensively used by Professor Hough, of the Dearborn Observatory, Chicago. For his fine series of measures, the formulæ necessary for the reduction of the measures to the central meridian, and his careful discussion of them, see the Annual Reports of the Dearborn Observatory, and especially that for 1882. From measures on thirty-one nights he found the mean error of a single pair of measures $\pm 0^m\cdot 9$, and $\pm 0^m\cdot 4$ for the average mean probable error for any day.

In conclusion, we may gather from the above notes that careful eye-estimates (the line joining the eyes being placed parallel to the belts), on good nights, and after some practice, will be worthy of confidence, and form useful contributions to the study of the phenomena of the planet.

Mr. E. Crossley's Observatory,
Bermerside, Halifax.

Note on the Period of T Centauri. By Alex. W. Roberts.

The minimum of *T Centauri* which took place in April 1896 happened at the same time as full moon, and so a direct determination of it was impossible.

Observations taken immediately before and after the minimum indicates that the minimum took place 1896 April 26. A minimum (observed both by Lieut.-Col. Markwick and myself) took place on 1895 April 26, and between these two dates there are four light variations, three of which have been observed at Lovedale. We thus obtain for *T Centauri* a period of 91·5 days, a period in satisfactory agreement with that already determined (*Monthly Notices*, March 1896, vol. lvi., p. 349), viz., 91·2 days.

In his *Ephemeriden veränderlicher Sterne für* 1896, page 2, Dr. Hartwig considers that a period of 360 days satisfies the earlier measures. Considering four periods to have taken place in 360 days we obtain a period of 90 days. Still some uncertainty must surround a determination of this kind, inasmuch as it is obtained simply from observations taken at or near maximum, and the maximum of *T Centauri* is not so distinctly marked as the minimum phase.

I hope by the close of the year to deal more fully with this, as well as with other southern long period variables; my present purpose, however, is fulfilled in substantiating the period given in the paper already referred to.

Lovedale:
May 1896.

Observations of Comet b 1896 (*Swift*) *made at the Royal Observatory, Greenwich*

(*Communicated by the Astronomer Royal.*)

The observations were made with the Sheepshanks' Equatorial, aperture 6·7 inches, by taking transits over two cross-wires at right angles to each other, and each inclined 45° to the parallel of declination. Magnifying power 55.

Greenwich Mean Solar Time.					Observer.	✐−★R.A.	Corr. for Refraction.	Log Factor of Parallax.	✐−★N.P.D.	Corr. for Refraction.	Log Factor of Parallax.	No. of Comps.	Apparent R.A.	Apparent N.P.D.	Comp. Star.
1896.	d	h	m	s		m s	s		′ ″	″			h m s	° ′ ″	
May	9	9	46	51	A. C.	+0 24·26	0·00	9·3795	+1 23·2	+0·2	0·8912*n*	3	2 6 19·73	26 9 24·6	*a*
	10	9	45	22	W.	+2 35·33	0·00	9·3230	−6 17·2	−0·8	0·8909*n*	6	1 59 24·59	25 17 25·1	*b*
	12	9	50	47	A. C.	+0 27·47	0·00	9·0713	−1 0·2	−0·2	0·8914*n*	6	1 45 13·44	23 45 39·7	*c*
	14	9	35	3	B.	−3 40·71	0·00	8·9696	+0 4·3	0·0	0·8870*n*	4	1 30 55·58	22 29 2·9	*d*
	20	9	54	18	A. C.	+4 3·49	0·00	9·4701*n*	−2 50 9	−0·4	0·8651*n*	3	0 47 24·48	19 44 46·4	*e*
	30	10	32	12	B.	−1 25·67	−0·02	9·9869*n*	+3 5·2	+0·2	0·7213*n*	5	23 36 53·09	17 34 14·3	*f*
June	1	10	43	2	A. C.	−4 18 24	−0·03	0·0324*n*	+4 22·3	+0·2	0·6644*n*	3	23 23 12·22	17 22 9·4	*g*
	5	10	41	9	,,	−2 44·78	+0·02	0·0719*n*	−2 13·8	−0·1	0·5733*n*	3	22 56 23·38	17 9 54·6	*h*
	6	13	23	25	B.	−0 51·81	+0·02	0·0551*n*	+3 25·1	0·0	9 2022	5	...	...	*k*

Notes.

The observations are corrected for refraction, but not for parallax. They are also corrected for the error of inclination of the wires and for the motion of the comet.

May 20.—Comet very faint and ill-defined, owing to moonlight.

,, 30.—Comet extremely faint, with very slight central condensation.

June 1.—Comet very faint.

,, 5 and 6.—Comet exceedingly faint and ill-defined; barely visible.

The initials A. C., B., W., are those of Mr. Crommelin, Mr. Bryant, and Mr. Witchell respectively.

Comparison Stars.

	Star's Name.	Assumed R.A. 1896·0.	Assumed N.P.D. 1896 0.	Authority.
		h m s	° ′ ″	
a	BD + 63° No. 305	2 5 56·91	26 8 5·3	Greenwich Observations, 1896.
b	Bradley 270	1 56 50·78	25 23 46·3	Greenwich Ten-Year Catalogue, 1880, and Observations, 1893, 1894, 1895.
c	BD + 66° No. 167	1 44 47·64	23 46 42·0	Pulkova Catalogue (Romberg), 1875.
d	ω Cassiopeiæ	1 34 38·06	22 28 59·5	Greenwich Ten-Year Catalogue, 1880, and Observations, 1888, 1891, 1894.
e	Groombridge 148	0 43 22·79	19 47 33·6	Greenwich Observations, 1894.
f	Oeltz. Arg. (N) 25964	23 38 19·82	17 31 0·0	Oeltzen Argelander (N).
g	BD + 72° No. 1107	23 27 31·29	17 17 37·5	Dorpat Astr. Gesell. Catalogue.
h	Oeltz. Arg. (N) 25078	22 59 8·34	17 11 58·1	„ „ „ „
k	BD + 72° No. 1071	22 49 55	17 5	Bonn Observations, vol. v.

Star *c* is the double star Σ 168. The companion is of the 12th magnitude.

Royal Observatory, Greenwich:
1896 *June* 12.

Meridian Observations of Comet b 1896 (*Swift*), *at Lower Transit at the Royal Observatory, Greenwich.*

(*Communicated by the Astronomer Royal.*)

Mean Time of Observation.	Observer.	Observed R.A. of ☄.	Observed N.P.D. (Corrected for Parallax and Refraction).
1896. d h m s		h m s	° ′ ″
May 1 12 13 52	W. B.	2 55 30·97	36 11 56·92
4 11 45 5	H. F.	2 38 29·07	31 39 23·33
9 10 53 3	A. C.	2 6 1·35	26 6 48·94
11 10 31 20	B.	1 52 8·29	24 27 57 76

The transit on May 4 was observed on four wires only, and these cannot be identified with certainty. It is possible that the R.A. should be diminished by one interval of the wires or $4^{s}\cdot7$.

The initials A. C., B., H. F., and W. B. refer to Mr. Crommelin, Mr. Bryant, Mr. Furner, and Mr. Bowyer respectively.

Cometary Observations at Liverpool Observatory, 1895.
By W. E. Plummer, M.A.

The following observations of Comets have been made with the Equatorial of the Liverpool Observatory during the year 1895. When the comet was sufficiently bright to admit of adequate illumination of the wires of a filar micrometer, the measures have been made with that instrument. With the fainter comets, or under unfavourable circumstances, a micrometer of thick wires, crossed at right angles and placed at an angle of 45° with the meridian, has been employed. In a few cases both forms of micrometer have been used, in order to judge of the relative accuracy of the two methods. Similar observations have also been made on nebulæ, and it appears that while the larger number of wires (nine) over which transits can be made with the filar micrometer gives a greater accuracy to the differences of Right Ascension, the declinations are fairly comparable in the two cases. Observations made with the crossed bars are marked "Ret.," and it has been usual to make five transits of the comet and comparison stars. All the observations have been corrected for differences of refraction, but no corrections for parallax have been applied, except in the case of Encke's Comet, mentioned in the Notes. The whole of the observations have been made by Mr. W. Plummer.

Encke's Comet.

Greenwich Mean Time of Observation.				✱−✱ R.A.	No of Comparisons (α)	Apparent R.A. of Comet.	✱−✱ Declination.	No. of Comparisons (δ)	Apparent Declination of Comet.	Log. Factor of Parallax in (α)	in (δ)	Letter of Reference.
1894.	h	m	s	m s		h m s	′ ″		° ′ ″			
Dec. 19	6	8	35·3	+4 46·11	Ret.	22 16 57·74	+ 0 29·9	Ret.	+ 4 37 39·3	0·3168	0·8208	*a*
20	6	3	9·2	−2 20·54	Ret.	22 16 41·87	− 1 6·1	Ret.	+ 4 30 36·7	0·3108	0·8215	*b*
20	6	3	9·2	+ 24·95	Ret.	22 16 42·02	+ 0 17·3	Ret.	+ 4 30 39·2	0·3108	0·8215	*c*
27	6	2	21·0	+1 35·20	25	22 15 7·13	+ 3 20·4	5	+ 3 40 22·8	0·4198	0·8278	*d*
27	6	2	21·0	+ 50·21	25	22 15 6·90	− 3 25·7	5	+ 3 40 21·5	0·4198	0·8278	*e*
30	5	31	47·4	−1 18·46	Ret.	22 14 23·42	+ 8 15·4	Ret.	+ 3 17 32·6	0·3541	0·8292	*f*
31	6	4	20·1	−1 35·04	27	22 14 6·86	+ 0 12·2	6	+ 3 9 29·3	0·4759	0·8314	*f*
1895.												
Jan. 8	6	4	16·0	−3 2·59	15	22 10 17·74	+ 1 39·7	4	+ 1 47 30·8	0·5584	0·8394	*g*
18	6	10	3·5	− 24·36	20	21 55 55·21	− 2 44·3	5	− 1 40 39·2	0·6511	0·8519	*h*
22	5	39	20·0	−3 25·04	Ret.	21 43 50·67	+13 5·2	Ret.	− 4 16 10·8	0·6489	0·8584	*i*
22	5	39	20·0	+1 11·72	Ret.	21 43 50·31	+11 59·6	Ret.	− 4 15 58·9	0·6489	0·8584	*j*
23	5	36	22·1	+1 4·57	20	21 39 58·16	+ 7 52·9	5	− 5 4 59·1	0·6594	0·8597	*k*
23	5	36	22·1	−1 56·30	20	21 39 58·07	+ 0 49·5	5	− 5 4 57·8	0·6594	0·8597	*l*

Notes.

December 19.—The comet very feeble, without any noticeable condensation.
December 20.—Wind very troublesome: clock seconds frequently inaudible.
December 30.—Comet well seen: condensation marked.
January 8.—Moonlight, but the observation was thought satisfactory.
January 22.—Altitude very small: greater difficulty in seeing the comparison stars than the comet.
January 23.—Observation difficult: comet very low. The comet was seen on January 25, but no suitable star of comparison could be seen.

This series of observations has been compared with the accurate ephemeris prepared by Dr. O. Backlund, and given in *Ast. Nach.*, No. 3263. The distances from the Earth and the times for aberration have been interpolated from that ephemeris, and the resulting comparisons are as follows:—

Date of Observation.	Observed R.A.	Correction for Parallax.	Seconds of Geocentric R.A.	Seconds of Tabular R.A.	Error of Ephemeris. C−O	Observed Declination.	Correction for Parallax.	Seconds of Geoc. Decl.	Seconds of Tabular Decl.	Error of Ephemeris. C−O
1894.	h m s	s	s	s	s	° ′ ″	″	″		
Dec. 19	22 16 57·74	+0·16	57·90	57·89	−0·01	+4 37 39·3	+ 7·5	46·8	59·6	+12·8
20	22 16 41·87	+0·15	42·02	42·56	+0·54	+4 30 36·7	+ 7·5	44·2	47·7	+ 3·5
20	22 16 42·02	+0·15	42·17	42·56	+0·39	+4 30 39·2	+ 7·5	46·7	47·7	+ 1·0
27	22 15 7·13	+0·21	7·34	7·31	−0·03	+3 40 22·8	+ 7·9	30·7	42·7	+12·0
27	22 15 6·90	+0·21	7·11	7·31	+0·20	+3 40 21·5	+ 7·9	29·4	42·7	+13·3
30	22 14 23·42	+0·28	23·70	22·85	−0·85	+3 17 32·6	+ 8·0	40·6	53·4	+12·8
31	22 14 6·86	+0·24	7·10	5·53	−1·57	+3 9 29·3	+ 8·1	37·4	36·7	− 0·7
1895.										
Jan. 8	22 10 17·74	+0·31	18·05	15·60	−2·45	+1 47 30·8	+ 8·9	39·7	40·3	− 0·6
18	21 55 55·21	+0·44	55·65	51·45	−4·20	−1 40 39·2	+10·4	28·8	68·1	−39·3
22	21 43 50·67	+0·45	51·12	45·55	−5·57	−4 16 10·8	+11·1	59·7	93·6	−33·9
22	21 43 50·31	+0·45	50·76	45·55	−5·21	−4 15 58·9	+11·1	47·8	93·6	−45·8
23	21 39 58·16	+0·47	58·63	52·36	−6·27	−5 4 59·1	+11·3	47·8	84·1	−36·3
23	21 39 58·07	+0·47	58·54	52·36	−6·18	−5 4 57·8	+11·3	46·5	84·1	−37·6

Swift's Comet (*a*) 1895.

Greenwich Mean Time of Observation.				✐−✶ R.A.	No. of Comparisons (*a*).	Apparent R.A. of ✐.			✐−✶ Declination.	No. of Comparisons (*δ*).	Apparent Declination of ✐.			Log. Factor of Parallax in (*a*).	Log. Factor of Parallax in (*δ*).	Letter of Reference.
1895.	h	m	s	m s		h	m	s	′ ″		°	′	″			
Aug. 24	12	19	7·0	−1 24·97	Ret.	0	36	29·22	−8 44·2	Ret.	+ 5	51	20·6	0·4751	0·8165	*a*
27	12	58	30·3	+5 14·81	15	0	43	9·06	+1 21·6	4	+ 6	1	26·7	0·3193	0·8121	*a*
28	12	6	19·1	+3 10·42	15	0	45	11·50	−6 37·2	4	+ 6	3	50·2	0·4909	0·8158	*b*
28	12	6	19·1	−2 6·56	15	0	45	11·03	−2 15·3	4	+ 6	3	51·7	0·4909	0·8158	*c*
Sept. 23	12	2	5·7	−0 55·29	Ret.	1	20	1·21	+8 20·7	Ret.	+ 5	14	42·0	0·2564	0·8163	*d*
23	12	2	5·7	+0 23·92	„	1	20	1·30	+3 40·8	„	+ 5	14	41·3	0·2564	0·8163	*e*
25	11	58	53·0	+0 16·14	„	1	21	12·65	−0 57·4	„	+ 5	5	23·9	0·2377	0·8171	*d*
25	11	58	53·0	+1 35·02	„	1	21	12·42	−5 38·7	„	+ 5	5	22·0	0·2377	0·8171	*e*
26	11	40	13·4	−0 25·11	12	1	21	43·92	+3 2·4	4	+ 5	0	46·7	0·3135	0·8184	*f*
27	11	55	22·0	+0 5·14	Ret.	1	22	14·19	−1 46·2	Ret.	+ 4	55	58·2	0·2190	0·8180	*f*
27	11	55	22·0	−0 2·44	„	1	22	14·11	+6 43·3	„	+ 4	55	52·8	0·2190	0·8180	*g*
28	12	9	32·3	+0 24·65	„	1	22	41·22	+1 57·4	„	+ 4	51	6·9	0·1015	0·8179	*g*
Oct. 13	11	13	22·5	−0 51·81	„	1	26	16·90	+6 3·5	„	+ 3	49	7·2	0·1070	0·8246	*h*
13	11	13	22·5	−4 37·57	„	1	26	16·57	+1 58·5	„	+ 3	49	4·1	0·1070	0·8246	*i*
16	12	0	40·0	−0 33·44	„	1	26	35·29	−2 43·9	„	+ 3	40	19·8	8·7982	0·8249	*j*
17	11	0	22·0	−2 0·87	„	1	26	40·84	+2 9·3	„	+ 3	38	0·5	0·0888	0·8257	*k*
18	9	57	42·6	−0 32·35	„	1	26	46·50	+2 34·5	„	+ 3	35	53·7	0·3964	0·8279	*l*

Notes.

August 24.—Comet faint and ill-defined.

August 27.—Sky hazy, comet very faint.

September 23.—Individual measures discordant.

September 26.—Haze; the observation very unsatisfactory. The reticule micrometer was tried on this night but the results were very discordant.

September 28.—Transits very irregular and uncertain.

In October the comet was very faint, but the observations fairly accordant.

Perrine's Comet (*c* 1895).

Greenwich Mean Time of Observation.				✐−✶R.A.	No. of Comparisons (*α*).	Apparent R.A. of ✐.			✐−✶ Declination.	No. of Comparisons (*δ*).	Apparent Declination of ✐.			Log. Factor of Parallax in (*α*).	in (*δ*).	Letter of Reference.
1895.	h	m	s	m s		h	m	s	′ ″		° ′ ″					
Nov. 18	17	14	21·1	+7 21·26	25	13	48	8·80	−2 15·2	5	+ 0 49 55·7			0·6951	0·8555	*a*
23	17	11	4·0	+0 34·90	20	14	0	36·94	−0 51·2	4	− 2 4 47·0			0·6926	0·8509	*b*
Dec. 1	17	34	16·3	+2 36·71	20	14	30	58·12	+7 17·8	4	− 8 54 58·1			0·6774	0·8641	*c*
2	17	59	6·4	+3 1·12	15	14	36	24·92	+1 46·1	4	−10 4 33·6			0·6537	0·8703	*d*
2	17	59	6·4	−1 17·33	15	14	36	25·18	+4 5·9	4	−10 4 37·0			0·6537	0·8703	*e*

Notes.

November 18.—Comet bright, with some indications of a tail.
November 23.—Comet well seen notwithstanding comparatively low altitude.
December 1 and 2.—Comet bright and easily seen; the comparison stars very faint on account of low altitude; sky transparent.

Brooks' Comet (*d* 1895).

	h	m	s	m s		h	m	s	′ ″		° ′ ″					
Nov. 28	16	40	30·0	−1 23·22	Ret.	9	25	56·43	−0 17·7	Ret.	+ 2 19 19·0			9·7988	0·8335	*a*
29	16	44	27·2	−1 55·23	,,	9	20	51·02	−7 1·9	,,	+ 6 14 32·6			9·4922	0·8075	*b*
Dec. 9	10	0	5·5	+1 46·10	,,	7	57	33·90	−2 50·3	,,	+48 35 40·6			0·8834	0·5522	*c*
9	10	0	5·5	+0 2·60	,,	7	57	33·57	+2 57·2	,,	+48 35 36·1			0·8834	0·5522	*d*
11	9	23	30·0	−5 23·41	,,	7	29	48·72	+7 46·3	,,	+55 9 15·5			0·9474	0·4550	*e*

Notes.

November 28.—Comet faint and without condensation. The centre of the nebulosity was estimated for the point of observation.
November 29.—The observations very discordant.
December 11.—Sky somewhat overcast. The differences of declination differ in the several transits.

Liverpool Observatory:
1896 *June* 10.

Mean Places of Stars of Comparison.

Encke's Comet.

Date.	Star's Designation or Authority for Places.	Mean R.A. Equinox of Year. h m s	Correction to Mean R.A. s	Mean Declination. Equinox of Year. ° ′ ″	Correction to Mean Declination. ″	Letter of Reference.
1894. Dec. 19	Albany, A.G.Z., No. 7744	22 12 9·27	+2·36	+ 4 36 53·9	+15·5	*a*
20	„ „ No. 7761	22 19 0·03	+2·38	+ 4 31 27·1	+15·7	*b*
20	„ „ No. 7754	22 16 4·71	+2·36	+ 4 30 6·3	+15·6	*c*
27	„ „ No. 7746	22 13 29·60	+2·33	+ 3 36 47·7	+14·7	*d*
27	„ „ No. 7747	22 14 14·36	+2·33	+ 3 43 32·4	+14·8	*e*
30	„ „ No. 7752	22 15 39·58	+2·30	+ 3 9 2·8	+14·4	*f*
31	„ „ No. 7752	...	+2·32	...	+14·3	*f*
1895. Jan. 8	Munich Cat., No. 30666	22 13 21·08	−0·75	+ 1 45 55·9	− 4·8	*g*
18	„ „ No. 30061	21 56 20·37	−0·80	− 1 37 57·9	− 7·0	*h*
22	Yarnall (1860) No. 9839	21 47 16·50	−0·79	− 4 29 8·0	− 8·0	*i*
22	Schjellerup, No. 8850	21 42 39·39	−0·80	− 4 27 50·5	− 8·0	*j*
23	Stone (Rad.), No. 5858	21 38 54·39	−0·80	− 5 12 43·7	− 8·3	*k*
23	Glasgow (1870), No. 5580	21 41 55·17	−0·80	− 5 5 39·1	− 8·2	*l*

Swift's Comet (*a* 1895).

Date. 1895.	Star's Designation or Authority for Places.	Mean R.A. Equinox of Year. h m s	Correction to Mean R.A. s	Mean Declination. Equinox of Year. ° ′ ″	Correction to Mean Declination. ″	Letter of Reference.
Aug. 24	Yarnall (1860), No. 359	0 37 50·93	+3·26	+ 5 59 42·3	+22·5	*a*
27	„ „ No. 359	...	+3·32	...	+22·8	*a*
28	60 Piscium	0 41 57·74	+3·34	+ 6 10 4·3	+23·1	*b*
28	Schjellerup, No. 303	0 47 14·26	+3·33	+ 6 5 43·9	+23·1	*c*
Sept. 23	Albany, A.G.Z., No. 396	1 20 52·78	+3·72	+ 5 5 54·9	+26·4	*d*
23	Bonn, D.M., 4°, No. 247	1 19 33·66	+3·72	+ 5 10 34·2	+26·3	*e**
25	Albany, A.G.Z., No. 396	1 20 52·78	+3·73	+ 5 5 54·9	+26·4	*d*
25	Bonn, D.M., 4°, No. 247	1 19 33·66	+3·74	+ 5 10 34·2	+26·5	*e**
26	Albany, A.G.Z., No. 402	1 22 5·28	+3·75	+ 4 57 17·8	+26·5	*f*
27	„ „ No. 402	...	+3·77	...	+26·6	*f*
27	„ „ No. 404	1 22 12·78	+3·77	+ 4 48 42·8	+26·7	*g*
28	„ „ No. 404	...	+3·79	...	+26·7	*g*
Oct. 13	„ „ No. 423	1 27 4·75	+3·96	+ 3 42 36·4	+27·3	*h*
13	„ „ No. 450	1 30 50·17	+3·97	+ 3 46 38·2	+27·4	*i*
16	„ „ No. 423	1 27 4·75	+3·98	+ 3 42 36·4	+27·3	*j*
17	„ „ No. 457	1 28 37·73	+3·98	+ 3 35 23·9	+27·3	*k*
18	„ „ No. 424	1 27 14·87	+3·98	+ 3 32 51·9	+27·3	*l*

* This star's place has been taken from the *Astronomical Journal*, No. 357.

Perrine's Comet (*c* 1895).

Date. 1895.	Star's Designation or Authority for Places.	Mean R.A. Equinox of Year. h m s	Correction to Mean R.A. s	Mean Declination. Equinox of Year. ° ′ ″	Correction to Mean Declination. ″	Letter of Reference
Nov. 18	Albany, A.G.Z., No. 4789	13 40 45·64	+1·90	+ 0 52 27·9	−17·0	*a*
23	Munich Cat., No. 9819	14 0 0·08	+1·96	− 2 5 21·1	−17·1	*b*
Dec. 1	„ „ No. 10285	14 28 19·33	+2·08	− 9 1 59·2	−16·7	*c*
2	Stone (Rad.), No. 3788	14 33 21·70	+2·10	−10 6 3·1	−16·6	*d*
2	Munich Cat., No. 10464	14 37 40·41	+2·10	−10 8 26·3	−16·6	*e*

Brooks' Comet (*d* 1895).

Nov. 28	Munich Cat., No. 4254	9 27 16·10	+3·55	+ 2 19 45·2	− 8·5	*a*
29	Paris Cat., No. 11654	9 22 42·54	+3·71	+ 6 21 44·2	− 9·7	*b*
Dec. 9	Bonn, A.G.Z., No. 6354	7 55 41·29	+6·51	+48 38 18·9	−12·0	*c*
9	„ „ No. 6375	7 57 24·48	+6·49	+48 32 26·7	−12·2	*d*
11	Helsingfors, A.G.Z., No. 5193	7 35 4·71	+7·42	+55 1 38·6	− 9·4	*e*